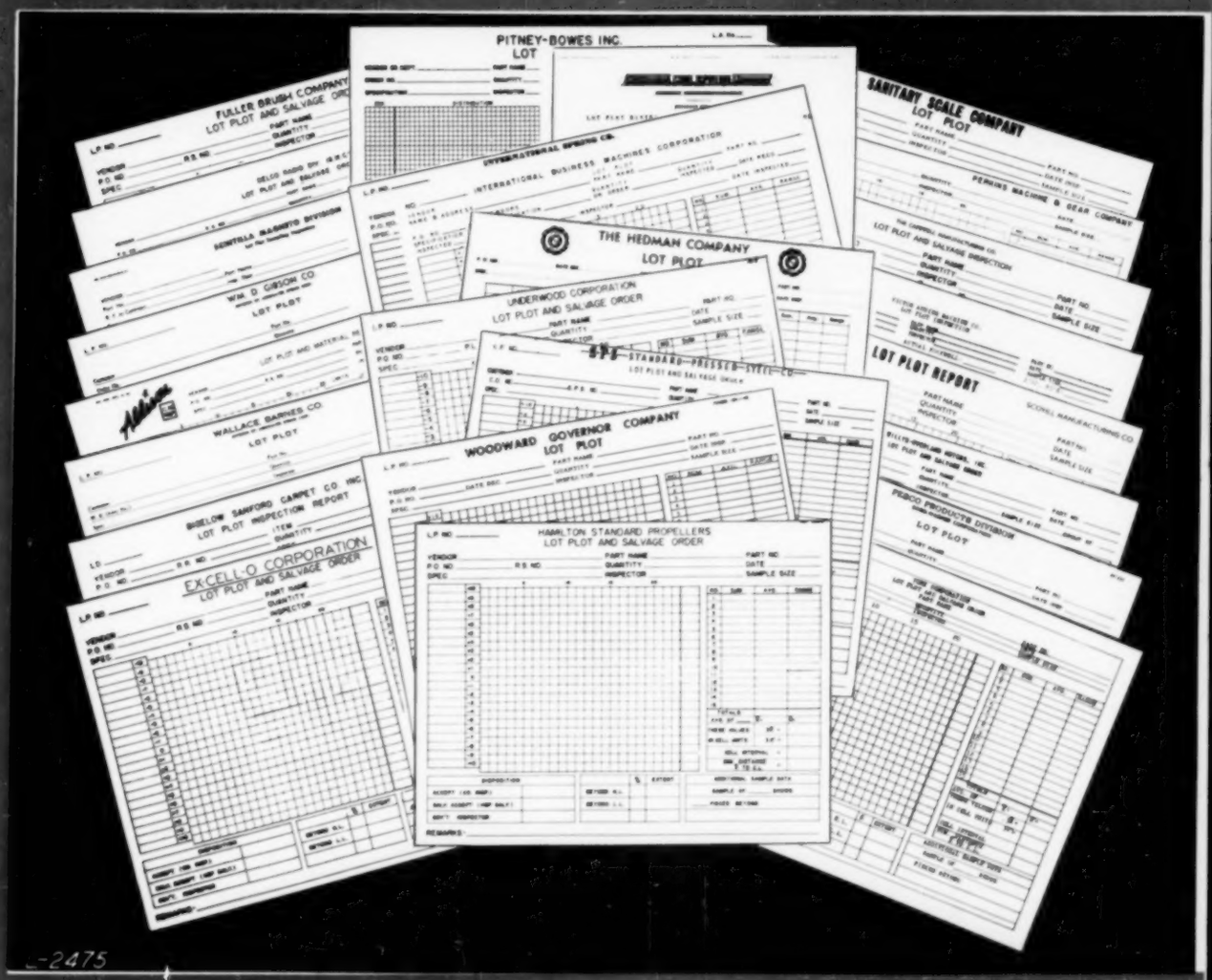
Industrial QUALITY CONTROL

JULY, 1950 VOL. VII NO. 1



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AMERICAN SOCIETY FOR QUALITY CONTROL

INDUSTRIAL QUALITY CONTROL

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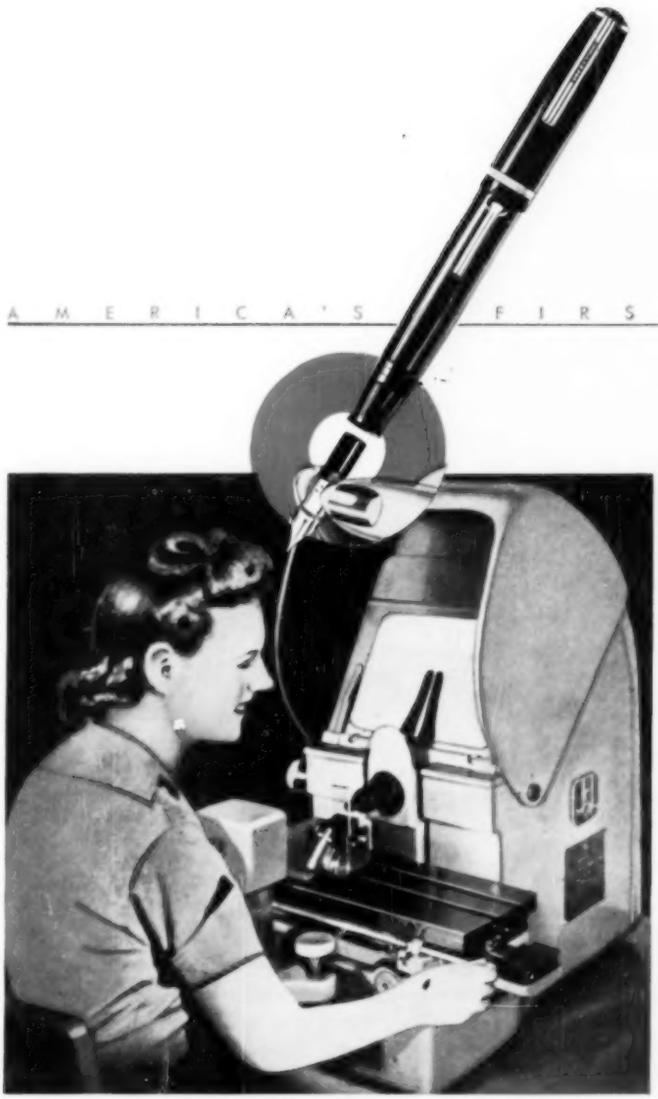

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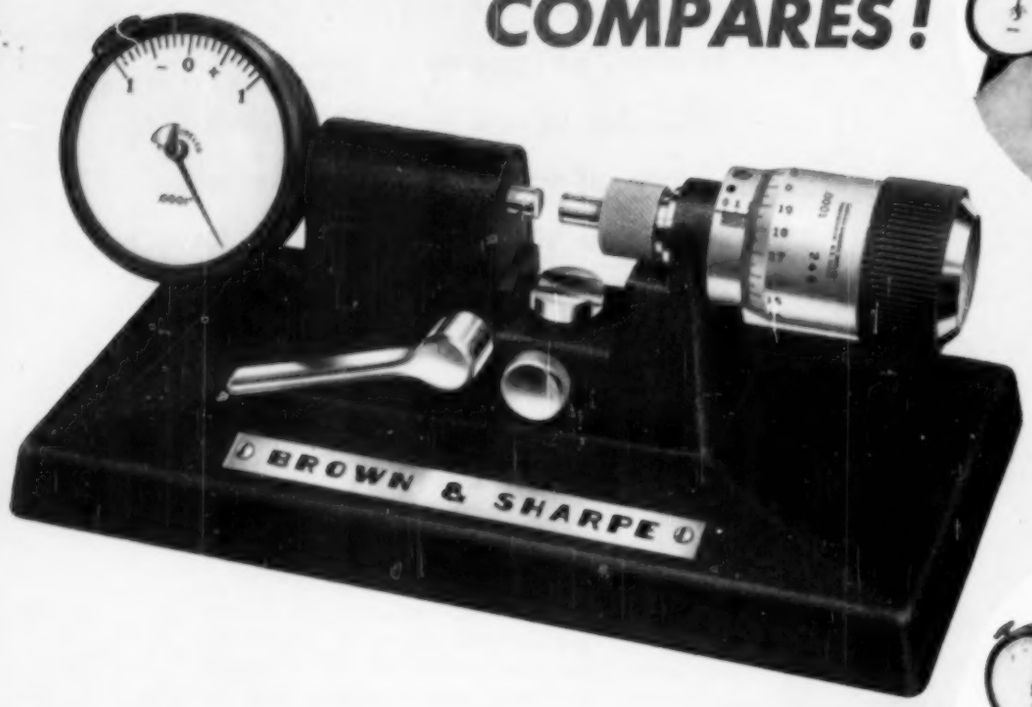

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This ten-working-day course, sponsored at the University of Connecticut at Storrs by the New England sections of ASQC, brings as instructors several people who are in part responsible for statistical techniques generally regarded as very helpful in making a quality control program complete, efficient, and — most important — practical. General Leslie E. Simon will explain the grand lot concepts and I_0 charts, John W. Tukey binomial probability paper, and Dorian Shainin the Lot Plot plan. Supporting this staff of development people will be Martin A. Brumbaugh, O. H. Somers, Warren R. Purcell, Simon Collier, E. V. Lewis, and Leonard A. Seder. Laboratory sessions will serve to knit all the material into a single, coordinated appreciation of "how to do it," and the course will close with an authoritative analysis by Dr. J. M. Juran of how quality control people can succeed in their relations with management.

Operating on a break-even budget, the value of such a *basic* course, as distinguished from an elementary or an advanced one, is expected to attract an enrollment that will permit including room, board, tuition and text material for the single fee of $125 per person.

Moreover, included is a "get acquainted" cocktail session led by Clifford W. Kennedy as an opening gun on Sunday evening, August 13th, and the services of a University student for the entire period extending to Friday noon, August 25th, as "Vice President in Charge of Affairs" to serve the incidental needs of enrollees, such as waking them each morning, procuring razor blades, cigarettes, ice water, etc. Mild athletic programs after classes are also hinted. Other and valuable surprise features will round out the program.

For further information on the University's Statistical Quality Control Institute, write Mr. G. C. Baldwin, Scovill Manufacturing Co., Waterbury, Conn.

Industrial Quality Control

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QUALITY CONTROL COURSE FOR THE CHEMICAL INDUSTRIES

An eight-day intensive training course in *Quality Control for the Chemical Industries* will be offered by the Rochester Institute of Technology at Rochester, N. Y., October 10-18, 1950. The content of this sixth annual training program in statistical methods and techniques is devoted exclusively to the control problems of the chemical and allied process industries. The course is designed for those responsible for controlling quality of product either in the analytical laboratory or directly in the manufacturing process.

The tuition of $100.00 per person includes books and supplies. Room accommodations will be available at the Hotel Rochester. Further inquiries should be addressed to the course coordinator, Alfred L. Davis, Rochester Institute of Technology, Rochester 8, New York.

Inspection For Quality Assurance*

HAROLD F. DODGE

Bell Telephone Laboratories

AT THE half-century mark, we are witnessing an increased emphasis on quality and on ways and means of producing better quality, more dependable quality, and at less cost. The American Society for Quality Control, through its many members and activities, is contributing in an important way to this movement. And there is every reason to believe that the curve of emphasis still bends upward. Quality control principles and methods, which are the special wares of our Society, are penetrating more and more into the several steps that contribute to the end quality of a product—starting with research, continuing with development and design, and culminating in a formal specification of requirements to be met, production in the factory, and inspection of both the parts and the completed product. What is done in each of these steps has a most important bearing on the end result. Of these several steps, I would like to single out one, namely, inspection, and discuss a few principles that should guide this step from the point of view of quality assurance.

SOME ASPECTS OF QUALITY ASSURANCE

By quality assurance will be meant the assurance that quality will meet the goal that has been set for it, as embodied in the intent of design specifications. In general, this goal is an over-all quality that is "satisfactory, adequate, dependable and economic". [1] I shall speak more particularly of products that are the result of repetitive manufacture, although the principles to be touched upon apply as well to other products of human activity, as for example, the output of manual and clerical operations in merchandising and office work, which are being statistically controlled with greatly reduced errors through the ingenuity of some of our members.

*Shewhart Medalist acceptance address, ASQC Banquet, Milwaukee, June 1, 1950.

Any manufactured product is the result of a series of operations and factors that combine to produce it. An expression of confidence in the quality of a supply of such product is essentially an appraisal founded on the constancy of behavior of the entire system of causes responsible for the product, including materials, machine operations, and human operations. Everything goes back to causes and their control. Factual evidence showing consistently good performance in the past becomes the basis for predicting good performance in the future. When we find ourselves dealing with a supply of product that we consider dependable, we can feel pretty sure that this state of affairs did not just happen. If experience is any guide, production processes do not become controlled of their own volition but rather through unrelenting human effort—experimenting, encountering failures and disturbances, finding out why things went wrong, correcting the causes, experiencing new troubles, and repeating the procedure over and over again. This is one of the basic tenets of quality control methods—finding out why things don't behave as they should, rooting out causes, and taking steps to prevent their recurrence.

Ideally, the goal is a constant system of causes, such that the resulting quality can be represented by the laws of mathematical probability and, hence, is subject to valid prediction. This is the concept that Shewhart [2] refers to as a "state of statistical control"—something to be sought even though it may not be fully attained under the hurried conditions of shop production. Experience indicates two things: first, that steps taken to control quality at a satisfactory level tend to reduce costs and, second, that once control is attained, it tends to continue. So we are encouraged to adopt these methods in the interests of achieving a quality that can be considered by the producer and consumer alike as dependable and economic.

ROLE OF INSPECTION IN QUALITY ASSURANCE

Now where does inspection fit into this picture if it is to contribute to the larger objective of quality assurance? I believe first of all that we must think of inspection. the analysis and use of its results, in terms of a preventive pathology rather than in terms of a curative pathology. Using inspection results as a basis for action on the product at hand for deciding whether to accept or reject individual articles or lots of product as they come along is, of course, an immediate chore that we always have with us. However, inspection results also provide a basis for action on the production process for the benefit of future product, for deciding whether the process should be left alone or action taken to find and eliminate disturbing causes [3]. Taking aspirin repeatedly may cure individual headaches—and headaches are data, make no mistake about it—but it is far more sensible to find out why we have headaches and then take steps to prevent recurrences. Here is the forward-looking attitude that we need to cultivate more intensely. Here is the way to make tomorrow's product better than today's. Preventing future troubles is a job to which inspection can make important contributions, but it can only be done with the cooperation of the other steps involved in turning out a product.

We can perhaps see the over-all problem more clearly by reference to a diagram that Shewhart [2] has published. He has indicated the advantage of looking at the three steps—specification, production, and inspection—not as three isolated separate functions but as coordinated parts of an over-all system of activities. He proposes that we consider them not as three straight lines in a row but as three arcs of a circle. We can then think of progressing from specification to production and on to inspection, and then continuing

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around the circle again, making the results of inspection available not only to specification for improving the requirements structure but also to production for improving processes. Viewed in this way, inspection provides live, continuing data which portrays the dynamic behavior of the underlying production process. It provides statistical information which we can use for long-term purposes if we only will. This is a guiding principle in practically all quality control work.

PLANNING INSPECTION FOR QUALITY ASSURANCE

What are some of the considerations that should guide the planning of inspection if it is to serve this larger objective?

First of all, inspection should provide good data. This may seem self-evident but too often it is taken for granted that all data, especially when recorded, are good data; that what is written down must be so. But of course measurements and observations are subject to error; and test equipment can get out of kilter. Quality control methods are particularly adaptable not only for developing precise and stable methods of test, but for maintaining test equipment and gauges in good order. The need for controlling the measurement operation is greater today than a decade ago, for with technological advances more requirements are falling in the so-called precision class. Methods of visual inspection and the performance of inspection personnel are sources of errors that are likewise subjects for careful analysis and control to provide assurance that comparable results will be obtained by different inspectors.

Second, inspection should provide information quickly. In this way alone can its results facilitate prompt action on the process when the need for correction or adjustment arises. This suggests that inspection be conducted as close as possible to the source of production and with a minimum of delay, for parts, components, subassemblies, as well as for finished products. For purchased parts or components, inspection at source rather than at destination will aid our objective. Further, the necessary amount of such inspections can be reduced if we actively encourage and aid the supplier to use quality control methods in his inspections and tests. We have barely scratched the surface of possible economies that could be realized by acceptance of product on the basis of the supplier's evidence of control, supplemented, to be sure, by occasional checks.

For parts and components made in our own shops, there are strong advantages in timing inspection close on the heels of production. Here the use of standard sampling inspection tables and of control chart procedures at the machine helps to provide information promptly. With intermittent short runs of production, so common for parts even in large-scale manufacture, these methods can be used effectively for approval of the initial set-up of the process and for periodic check sampling during production to determine the acceptability of product and to verify the set-up. If something goes wrong, correction of process can be made promptly before large quantities of non-conforming material are produced. In contrast, think of the troubles that ensue if large lots are accumulated and a sampling inspection of the mass discloses at a later date that a substantial but unidentifiable portion of the lot is defective.

Third, the inspection procedure should provide an incentive for production to control quality at a satisfactory level. Broadly speaking, procedures involving sampling inspection and rejection of lots are more effective from this point of view than 100% inspection and rejection of individual pieces. The production man tends to take it as a matter of course if individual defective pieces are returned to him for repair. He is glad to do this; he of course wants the product right. But if entire lots are returned to him for correction, as when sampling inspection is used, the steady outward flow of product is interrupted. With repeated lot rejections it becomes necessary for him to find and eliminate causes in order to prevent further lot rejections. This is an indirect power of acceptance and rejection by sampling—it induces correction of faulty processes. This principle lies behind the procedures associated with a number of published sampling inspection tables [4] [5] [6] [7] [8]. In the light of these considerations, 100% inspection and sorting of individual pieces can advantageously be regarded as a production function rather than as an inspection function [9].

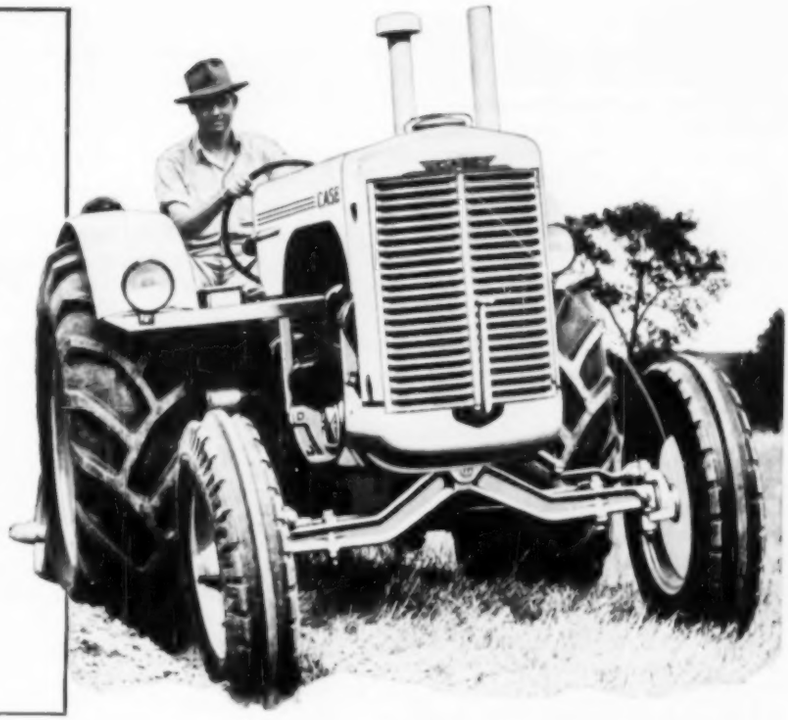
And last, the quantity of inspection should depend on the quality history of the product offered for inspection. A product with a history of consistently good quality requires less inspection than one with no history or a history of erratic quality. Accordingly, it is good practice to include in inspection procedures provisions for reducing or increasing the amount of inspection, depending on the character and quantity of evidence at hand regarding the level of quality and the degree of control shown. This principle has been incorporated in published sampling tables for go no-go inspections. In like manner, control chart inspections in process can properly include provisions for reduced frequency of drawing samples when good control at a satisfactory level is in evidence and for more exhaustive inspection whenever trouble is indicated.

INSPECTION AS A COORDINATING AGENCY

What are some of the things that might be done to enable us better to achieve the objectives of quality assurance? What does inspection have to suggest?

To begin with, inspection deals with other people's troubles as well as its own, because of the judicial nature of its job. Many difficult questions arise in a day's work. Is the method of measurement furnished by the research or development group a stable one, capable of giving reliable data day after day? Are the specification requirements ambiguous or incomplete? Are the specified limits tighter than really necessary? What percentage nonconformance to specification can be considered acceptable as an economic minimum? Does production sometimes knowingly submit marginally substandard quality, hoping that it will get by? Should marginally substandard material be accepted as nonconforming? Considering these questions, one thing seems clear. Others besides those in inspection are involved, and satisfactory answers are not forthcoming if one group merely says to another, "That's your problem." Rather, the solution seems to lie in the close coordination of the several steps that contribute to the end quality of

THREE THINGS Make a Product Great



Three things make an industrial product great. There is the creative thinking that goes into its inception and design. There is the skill in the hands of the men and women who build it and send it on its way. And there is the excellence of the steels, the rubber, the wood and the fabrics that are shaped into the form and function of that product. All are bound inseparably by the time-tested integrity of the manufacturer.

Excellence of materials! Therein is embraced much of science and all of an art—quality control. It is the rigid adherence to exact specifications in raw materials, and the constant testing of random samples as they converge at the assembly line, that have won for Case farm and industrial tractors and Case farm machines their proved endurance, their world-wide esteem for more than a century.

Long a leader in the big-power class, the Case Model "LA" tractor owes its leadership to this three-fold industrial idealism. Its famous forebear, the doughty Model "L," led the field for many years. Even today there are Case "L" tractors in hard daily use after more than 20 years—and still going strong. This remarkable longevity and customer satisfaction bear testimony to the Case practice of quality control. J. I. Case Co., Racine, Wis.

America's favorite combine, the 6-foot Case Model "A," is another example of correct design given endurance by quality control. The continuing good work and long life for which the "A" combine is famed are results of the Three Things—creative thinking, honest workmanship, and quality control.

CASE

product—research, development, design, specification, production, and inspection—through cooperation and teamwork of those engaged in these different activities. Such coordination calls for lowering of barriers that may exist between groups, perhaps through joint educational sessions, in order to provide a better mutual understanding of the relation of these several steps, all of which have a common goal.

Inspection can contribute to such coordination by the preparation of inspection procedures which define the kind and quantity of evidence to be considered adequate as a fulfillment of the intent of design. Such procedures may include information on the division of product into inspection lots, selection of samples, the acceptance criteria, the disposition of nonconforming product, etc. Just any old sampling plan won't do, as for example, one that was discovered during the war: Look at five; if any *one* is good, accept the lot. The selection of sampling inspection plans involves a consideration of appropriate risks of sampling as well as acceptable percentages of nonconformance to specification, with the following things in mind: seriousness of different types of defects if they reach the consumer, production capability and costs, and the cost of inspection itself. These are matters to be decided judicially with the cooperation of the specification and production groups. Here, most careful consideration should be given to the advantages of making formal inspection procedures supplementary to, not a part of, design specifications.

Again, inspection can contribute to a program of coordination by making available quality reports indicating the quality objective and the degree to which it has been attained. Such reports can aid in showing whether failures to meet the mark are attributable to shortcomings in specifications or to faults in production.

As a specific suggestion affecting all groups there are strong advantages to be gained from a long-term standpoint by an active program of coordination and cooperation in advance of drawing up final specifications and starting regular production. To this end much can be accomplished by what has been referred to as preproduction or pilot production; that is, preliminary production on a small scale under shop conditions with participation by the several interested groups. Under this arrangement troubles can be discovered early and corrected, understandings can be reached, and modifications of specification requirements and of processes can be made with relative ease. Production has an opportunity to correct unforeseen causes of erratic variation and to develop a stable process, design and specification can find out what tolerance limits are attainable, and inspection can work out inspection procedures that can be used as a practical interpretation of the quality goal that all have in mind. Changes and adjustments at this time are much less difficult and costly than the same changes would be once the wheels of regular production start turning and production personnel settles into routines. Experience indicates that a little time spent in coordinating efforts and viewpoints in the preliminary stages is time well spent from the standpoints of quality and economy.

In conclusion, inspection should plan and conduct its work in such a manner that the information it gathers will be of maximum assistance to others. It can contribute to closer coordination of the specification, production, and inspection functions and to a better understanding of the interrelationship of these activities. Although much progress has been made in a number of diverse fields, we still have a long way to go, and the challenge is before us to use more efficiently the principles and methods of quality control in order to provide us with assurance that quality will be satisfactory, adequate, dependable, and economic. We have an even greater challenge to bring to yet untouched fields the benefits to be gained by applying these principles and methods which are so fundamental to the American Society for Quality Control.

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[1] Shewhart, W. A., "Some Aspects of Quality Control", Mech. Eng'g., Vol. 56, Dec. 1934.

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[9] Juran, J. M., *Management of Inspection and Quality Control*, Harper and Bros., New York, 1945.

ADVANCED COURSE IN STATISTICAL QUALITY CONTROL — PURDUE UNIVERSITY

An eight-day advanced course in statistical quality control will be offered by Purdue University Sept. 8-16 inclusive. This course is intended to meet the needs for additional training of men and women who have had some previous instruction or practical experience in the subject.

Topics to be offered are: review and background of control charts, significance of differences, principles of acceptance sampling, sequential analysis, both attributes and measurements, linear and multiple correlation, analysis of variance, tolerances of fitting parts, chi-square, and use of calculating machines.

Prerequisites are a first course or its equivalent. The emphasis will be on applications, and all techniques will be explained as simply as possible.

Tuition is $100. For additional information, write to Professor Irving W. Burr, Department of Mathematics, Purdue University, Lafayette, Indiana.

What Management Expects From Quality Control*

LEWIS D. CRUSOE

Vice President, Ford Motor Company, and General Manager, Ford Division

IT'S A very great pleasure and privilege for me to have this opportunity to participate in your annual convention and midwest conference. I welcome the chance to get out among men who are doing so much to push upward the standards of quality in American industry —men who are setting the pace in quality control.

MANAGEMENT'S CONCERN FOR QUALITY

I don't know of any problem to which management is giving more serious and intelligent consideration today than that of quality control. All of us know that, in the post-war rush to re-establish production, quality was too often the tail of the kite instead of leading the parade. The good merchandiser is fully aware that there can be no compromise on quality, that the American consumer demands and will get quality merchandise or he will not continue to buy.

Under these circumstances, it is not surprising that there has been such great progress in the development and application of quality control systems to a wide variety of manufacturing and other processes. When you consider that, only a few years ago, quality control was a relatively unexplored and unorganized field, the list of topics for your clinical sessions becomes all the more impressive.

As a comparative layman in statistical quality control, I must admit that I'm somewhat taken aback by such terms as "specific deviation," "reject/production ratio," "X double bar" and "sigma prime." I realize, of course, that they are definitions and symbols of a fast-growing body of knowledge that is necessarily technical in nature.

However, I hope this doesn't mean the development of a new and inscrutable language that will narrow quality control to a field for technicians. If we agree that quality must be the concern and the goal of everyone on the production team, then I think we must deal in plain, clear terms that will have meaning even for the man who sweeps up the floor between shifts.

To go right to the point of my remarks today, it seems to me that, in our preoccupation with all the technical phases of quality control—charts, graphs, systems and standards—we cannot afford to underestimate or slight the vital *human* factor in all these calculations. Quality can never be any better than the "will to do" of the man—and the supervision—doing the job.

Management expects a great many benefits from quality control. It looks, naturally, for better quality. It looks for increased production and lower costs. It looks for greater customer satisfaction.

But at the same time, I'm sure, management expects quality control to develop a closer, more satisfying relationship between the worker and his job. It expects that, in any quality program, there will be an increased sense of responsibility and a more conscientious job-attitude on the part of men and women on the production line as well as all supervision. This is something I believe management can and should expect from quality control.

Although many companies, including my own, are tackling this human side of the quality problem in a great many ways, I wonder if we are getting at the real source of employee cooperation for quality production. Certainly we can make use of training courses, quality slogan contests, posters, scrap exhibits and all the rest. They help to make the employee quality-conscious and spur him to greater effort.

But I think we can do a lot more by tapping the deep human urge within all of us to do a good job and to be proud of our work. There aren't many people who are really happy with just getting by. But there are a certain number in our world who are satisfied to just "take" from our civilization without adding anything. That's not only true of some production workers, but of some of the rest of us.

Most of us fortunately would much rather be proud of what we do and want others to be proud of it too.

THE NATURE AND NECESSITY OF "PRIDE OF PERFORMANCE"

What I'm talking about is something called *pride of performance*, the kind of thing that makes the farmer want to send his prize products to the county fair, to show his "know-how," to dramatize his daily efforts—the kind of thing that makes the armed services tell their new recruits to "Wear that uniform as though you're proud of it."

Pride of performance has been an important part of our American tradition. We take great pride in what we do. And we don't always work just for money. I'm sure the desire for money and all it represents is a big factor with most of us—but it certainly isn't everything. That's where we have fooled our friends—and enemies—over and over. Sure, we like to make money. But beyond that, we like to do things well. We like to *have* the best—to *grow* the best—to *build* the best—to *make* the best.

We as a people are vastly proud that we have so much of the biggest and the best. And we're never content until we get the best—the biggest and fastest airplanes, the best-looking and most efficient cars, the most effective munitions, the best fitted fields—we must have the best.

*Luncheon address, Fourth National Convention, ASQC, and Fifth Midwest Conference, Milwaukee, June 2, 1950.

And we seldom give up until we get it.

It seems to me that we in the United States owe much of our success to the pride that we as a people —from the time our country was founded—have had in what we have done. Our highways, our baseball teams, our banks, our ice cream cones, our industries, our juke boxes, our schools—in fact, our standards of living—are better than those of anybody else. We are proud of that. We get satisfaction from the knowledge of that fact—satisfaction that can't be measured in terms of material things.

We don't lead in all fields. I don't mean to imply that we do. Other countries still outdo us in terms of such things as art galleries, museums, and cultural centers—to name a few—but by and large we lead in those fields in which we have made a concerted effort to succeed.

The people in this country seem more interested in *living* things than in relics of the past. *Our* best museums are the living exhibitions of the progress we have made—the streams of automobiles on the boulevards and highways, the farmers in the fields with their tractors and modern equipment, the planes coming and going at the busy airports, the livestock and produce at the county fairs—those are the things we like to see.

But, unfortunately, there are some people who take these things for granted, who fail to sense and share the tremendous pride of accomplishment that goes with work well done. It seems to me that there has been more and more of an inclination among people to forget the importance of this thing which has helped to make our country great—this thing which we call pride of performance.

I could be wrong, of course, but the evidence appears to be unmistakable. There seems to be an ever-increasing attitude on the part of people in every walk of life to say of the jobs they turn out, "This is good enough," rather than "This is my best. I'm proud of it."

Maybe the tendency of so many people to have such an attitude is the price we are paying for prosperity. Our standard of living is now at the highest point it has ever reached. But maybe our national failure to pay as we go is killing off the spirit of competition. I hate to think so, but we shouldn't overlook the possibility.

Competition is born and bred in pride of performance or pride of accomplishment. People who are proud of their ability, proud of their work, are eager to excel. I don't mean cut-throat competition, the kind that operates at the expense of the other fellow. The kind of competition I'm talking about is the intense, but friendly, rivalry you find at automobile shows, or in amateur sports or—for that matter—among the precision-equipment exhibitors at this conference.

One of the best things about this kind of competition is that it promotes tolerance and a healthy respect for the other fellow's work and ideas. In doing this, it is one of the finest expressions of our democratic system. We have only to look at those countries where it has been eliminated or discouraged—or where it has never been known at all—to realize its value. I think you will agree that we ought to promote whatever means we can find for furthering that healthy competitive spirit.

Or perhaps this tendency to try just getting by is one of the penalties that go with our emphasis on specialization. In an earlier day, the cobbler or the tailor or the carriage-maker had the satisfaction of turning out a finished product all by himself. From raw material to the completed shoes or suit or carriage, it was *his* job, *his* responsibility, *his* reward when the consumer was well satisfied.

Today, with manufacturing broken down into hundreds of separate, though highly integrated functions, it is often difficult for the man who machines one small part to achieve that same satisfaction or to take pride in having such a small share in the finished product. His satisfaction and pride must come from the knowledge that he has done his part of the job well and that the final product is a better one because of his workmanship.

We reward the inventive mind, but the only reward for the careful mind is pride of contribution to our welfare and our system of life.

Certainly none of us would want to give up the benefits of mass production and specialization in favor of the old one-man system, but we must seriously consider the effect of technological changes upon the worker's pride in his job. At any rate, I think we should look for the causes of this lack of job-pride and do what we can to eliminate them. This is especially necessary in industry. There, because of the large numbers of people and the many different kinds of jobs involved, it is much harder to isolate cases of lack of job-pride than it is in other pursuits.

The airplane mechanic, for example, takes the first ride in the plane he repairs—you can be sure he has pride in his work.

It's easy to look at a baseball team and tell which players are really trying hard and which are not. The whole picture is right there before your eyes. It's another matter, though, to look at an automobile and tell which of the workers who made the car did good jobs and which ones just got passing marks. And yet the good automobile or the good refrigerator or the good electric light switch is just as dependent upon pride of performance as the good baseball game.

Organizations are just human beings grouped together for a joint productive effort of some kind. Because some companies are so big, people sometimes tend to regard them as automatic, unfeeling machines, which we know isn't so. Companies *are* people.

The products turned out by an industrial concern are as good or as bad as the workmanship of the people—the human beings—who make up the concern. That's why the same products of a single business can vary so much. In spite of the increasing use of machinery in our plants, the human element is the controlling factor. And there's nothing wrong with that. It is only when the human element—labor or management—does a poor job that we need to worry.

Our problem today, as I see it, is not that the human element is doing a poor job, but that in many cases it is not doing as good a job as it can do. Those men and women who are simply putting in time and turning out a certain amount of work are certainly not giving their best. They do not have—cannot have —pride of performance. And certainly they are not greatly concerned with quality.

PRIDE OF PERFORMANCE IS THE ROOT OF REAL QUALITY

The need is for mass education in pride of performance at every level.

It is here, I think, that we should concentrate a great deal of our efforts to achieve quality production. Statistical controls, inspection devices and other technical methods cannot be fully effective without quality workmanship.

As I see it, the quality in a Ford car walks into our plant every morning on two legs. That workman or supervisor may have good, capable hands, skillful enough to do any kind of job required of them, but if those hands are not directed by the right kind of mind—the kind of mind that directs them to do their best and to do the job right the first time—then we are losing the basic approach to quality.

It is amazing to me that many people who take great pride in the way they keep their homes, or in their fine gardens, or in the condition of their cars should fail to carry that pride of performance into their jobs. And it is even more amazing that many who wouldn't dream of cheating others at home somehow think they can let down when they enter a big system of some sort and become one worker among many.

I think that too many of these people rely upon the system to cover up their mistakes and careless workmanship. They feel that if there's anything wrong with the job they're doing, someone else will spot it and fix it up or that it will never be noticed at all. There's that kind of attitude to be reckoned with constantly in any large-scale operation where faulty workmanship is not readily noticeable. Quality is just not inspected into a job. You all know what happens to a half-inch water system if hidden in it somewhere is a quarter-inch coupling.

In my opinion, there's nothing that hurts a man like doing a shoddy job underneath and then glossing it over. A man like that is a plain cheat and he can't hope to hide the fact for long. There's a lot of difference between correcting an honest mistake and glossing over the mistake to make it appear like a good job. One is a sincere effort to do the right thing, the other is sheer dishonesty.

I believe that we must emphasize again and again the fact that quality is much more than a bright, shining product with all the attractive, eye-pleasing features that the average customer looks for.

Quality is more than skin deep. Poor quality in a product is caused by little things, underneath things which can't be inspected in—or out. The good workman knows that, but others must be impressed again and again with that fact's importance.

I like to think of it this way: We make cars by the millions but we *sell* them one by one.

Many of you will recall the splendid accomplishments of industry during the war years when quality production was not only desirable but vitally necessary. Hundreds of thousands of relatively unskilled workers went into jobs that might ordinarily have required months of training. And those workers, with few exceptions, produced quality weapons and materials of all kinds.

We won the war not only because of our military superiority, but because of the things we did with our hands—because of the gigantic flood of top-quality guns, tanks, airplanes, munitions and other supplies that we kept flowing to the fighting fronts. And what we did with our hands was possible only because of our mental attitude—our determination to do the best kind of job we could.

You may remember our experience with tanks. We worked and slaved to get tanks into production and they finally started to roll out of the plants. We patted each other on the back and said to ourselves, "Now watch those Nazis back up." We were proud of what we had done. Thousands of people had worked like beavers to get these tanks rolling. They had a great deal of pride —and purpose—in their work.

But no sooner did we get those tanks into combat than we discovered that the enemy had bested us—that our tanks just couldn't stand up to his. That was a blow—a terrific blow—but it didn't stop us. We were bound to do better. Our pride was wounded—here was a product of our efforts which wasn't the best. So the thousands of people buckled down and went to work all the harder. They produced tanks that did excel—and we are all familiar with the final result.

Not only in tanks, but in planes and ships and guns and ammunition those hundreds of thousands of war workers put quality. They wanted to be proud of what they were doing, proud of their work, and they wanted our fighting men—their sons and brothers and all the rest of the country—to be proud of them and their work, too. That pride of performance paid off in a big way.

What I'd like to suggest is that we shouldn't need an emergency of that kind—a tragic conflict between nations—to inspire pride of performance in all of us. Good workmanship and job-pride are just as important now as they were during the war. While the demands upon us are not as urgent and pressing, the stakes may be every bit as high as they were during the war years.

It is my belief that without pride of performance, we as a people—as a nation—would really have nothing. We would be through as a world leader. We would have less and less stature in the family of nations—and internally our way of life could not help but worsen and degenerate. The proverbial "shirt sleeves to shirt sleeves" *could* happen to a *country*, too, for a country is just people.

Our whole economy, our whole way of life has been based upon the idea that we must give value for value received. Mass production was possible only because people knew they were getting their money's worth—and more—when they bought the products of mass production. The only reason any of us buys anything of any value is that we believe it is worth more to us than the money we pay for it.

What we buy, of course, is workmanship. In fact, the only thing that business and industry have to sell is workmanship, backed by the honor and honesty of a company and its people. Even the services—transportation, light, heat, news and all the rest—depend upon quality workmanship in the first place.

Of course, there must be capital to underwrite this workmanship. It is capital which makes the products of skilled hands and minds available to all of us. But, by the same token, there must be workmanship to make capital useful.

In industry, we proceed on the basis that we have honest work to sell in the form of a tangible product. For that reason, we must make every effort to get honest work from all our employees — supervision, managers — the entire team. And there must be honesty in the very design of our products. Unless we get honest design and honest work, we might just as well not try to do business.

To put it another way, a million-dollar payroll means a million dollars worth of workmanship. If it doesn't, everyone is a loser.

In the automobile industry, we have to provide the eventual customer with a good car—one that will be worth the price he pays for it. To show good faith, buyers receive warranties or promises to make good certain defects or faults which may become apparent within certain periods after the purchase has been made. What we're doing, in effect, is underwriting the attitude of our mechanics. On that basis, we must demand and we must get honest work or we won't last in business. It is the same in any industry or company, whether there are warranties or not. Unless a customer gets good workmanship for his money, he will no longer be a customer. The company—not the individual—gets the first complaint letter. But the security of any individual is no better than the product and the security of his company.

I like to look at our job at Ford Motor Company this way: Instead of looking for car buyers, I want people to want us to do a job for them. I want them to come to us for workmanship.

Perhaps I have seemed to be going at the problem of quality production in a rather indirect way today. But it seems to me that where there is work of any kind to be done, there must be good workmanship.

And workmanship is synonymous with quality.

While I believe that we should go ahead with all speed in the development and improvement of quality control techniques and systems, I believe that we must at the same time make a continuous and determined effort to restore and strengthen wherever necessary the spirit of fine workmanship—the pride of performance—that has helped to make this country great.

This is a job for all of us to do in our own plants—and in our own ways. It is a far greater challenge than is offered by the more easily solved technical or scientific aspects of quality control. If we can meet it successfully, we will make a significant contribution to better products and better living for all our people.

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The Hamilton Standard Lot Plot Method of Acceptance Sampling by Variables

DORIAN SHAININ

Chief Inspector, Hamilton Standard Division, United Aircraft Corporation

EDITORIAL NOTE

This paper is being published in response to popular demand for its appearance in Industrial Quality Control. The author has purposely chosen to hold to a minimum discussion of theoretical aspects in order to emphasize operational procedures. The techniques described in the paper have enjoyed a wide exposure in various industries and have thus far met successfully the exacting test of in-plant use. Despite the fact that the full support of a detailed and critical analysis of the theoretical structure of Lot Plot techniques in their entirety still remains to be made, it is believed that the plan as herein described presents a set of procedures sufficiently sound in theory and flexible in practice to provide trustworthy and useful information in acceptance sampling by variables situations, and to do so with marked improvement in inspection costs and efficiency.

Reprints of this paper may be secured at 50c per copy. Requests for permission to reprint privately will be honored provided proper source credit is given to Industrial Quality Control and the name "Lot Plot" is retained on all forms and literature pertaining to the plan. The author would appreciate receiving a few blank copies of the Lot Plot form from new users with their name on the form replacing that of Hamilton Standard. He will be glad to send a few copies of his forms upon request, as they may assist in preparing new ones.

Orders for reprints should be sent to Alfred L. Davis, Rochester Institute of Technology, Rochester 8, N. Y. Requests for reprint privileges should be sent to Mason E. Wescott, Lunt Hall, Northwestern University, Evanston, Ill.

Questions pertaining to details of the plan as set forth in this paper should be sent directly to its author at East Hartford 8, Conn.

—Mason E. Wescott.

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100% inspection; comparative test results; OC Curve

INTRODUCTION

Because considerations of safety, ability to function properly, and interchangeability are so important to the aircraft industry, it has been traditional to require 100% inspection for at least all important specifications. The increasing national recognition that 100% inspection is not even close to 100% effective, in most instances, led us to search for a more effective method. We came across the article "Frequency Distribution vs. Acceptance Table," by G. R. Armstrong and P. C. Clarke of Hunter Pressed Steel, published in the September 1946 issue of **Industrial Quality Control.** With the help of two members of my staff, Messrs. F. B. Murphy and T. W. Read, we developed Hunter Pressed Steel's idea into the "Lot Plot" plan.

This plan embodies features of Dr. W. A. Shewhart's well-known and most effective control chart for variables (plus the feature of the successful estimation of standard deviation by the use of range, from the work of Messrs. E. S. Pearson and L. H. C. Tippett) as well as what may be some original applications of statistical methods and probability concepts. It is devised to be primarily a practical plan that can be administered economically in a factory. After reading this paper through the first time one may logically wonder about the word "economically." However, with proper instruction and about one week's experience with using the plan, the average inspector becomes quite proficient at it.

I. THE PROBLEM

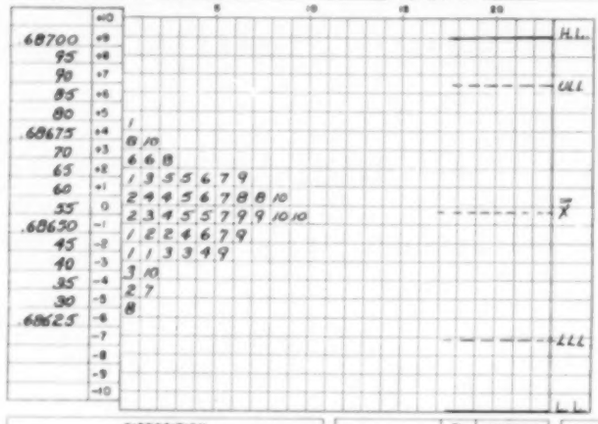
The problem, briefly, was how to improve (this point will be elaborated on later) upon the conventional 100% inspection of purchased material of all sorts that would be received from vendors in varying lot sizes and at irregular intervals. Obviously, the sampling would not be in the order of production, and it is to be remembered that preserving that order is a very important requirement contributing to the effectiveness of an $\bar{X}$,R chart. Moreover, the material very often would not be fabricated under statistically controlled conditions. Accordingly, out-of-control points would sometimes be indicated on such a chart. However, such an entire lot could still be within specification limits. In short, while the $\bar{X}$,R chart is most effective at the point of fabrication, it is not economically or even well suited to acceptance sampling for receiving inspection, since the product of processes that are not running in control, when mixed, can be expected to show a condition of apparently being in control.

Conventional methods of acceptance sampling by variables are based upon given risks corresponding to AQL and RQL (acceptable quality level and rejectable quality level) and then mathematically determining the required sample size. The acceptance decision is based on whether the average of the sample for the characteristic in question is contained or not within computed limit lines, the positions of which depend upon an estimated standard deviation (from previous experience) and the sample size. Aside from the very real danger that the standard deviation of the lot in question may not be even nearly the same as it has been in the past, this method requires that the distribution of the lot be nearly normal.

L.P. NO.: _____

HAMILTON STANDARD PROPELLERS
LOT PLOT AND SALVAGE ORDER

VENDOR X.Y.Z. Co, Rochester, N.Y. PART NAME Retainer PART NO. 55037
P.O. NO. 243524 R.S. NO. 297519 QUANTITY 1453 DATE 2-17-44
SPEC. .687 +.000 -.001 O.D. INSPECTOR T.J. SAMPLE SIZE 50



NO.	SUM	AVG.	RANGE
1	+2	+.4	7
2	-5	-1.0	5
3	-5	-1.0	5
4	-1	-.2	3
5	+5	+1.0	2
6	+8	+1.6	4
7	-2	-.4	6
8	+9	+1.8	9
9	-1	-.2	4
10	+2	+.4	7
11			
12			
13			
14			
15			
TOTALS		+14	52
AVG. OF 10		$\bar{X}$ = +1.4	$\bar{R}$ = 5.2
THESE VALUES		$3\bar{R}$ =	15.6
IN CELL UNITS		3σ =	6.76
CELL INTERVAL =			.00005
DIM. DISTANCE X TO L.L. =			.00034

DISPOSITION	
ACCEPT (CO. INSP.)	
SALV. ACCEPT (HSP SALV.)	
GOV'T. INSPECTOR	

	%	EXTENT
BEYOND H.L.	OK	
BEYOND L.L.	OK	

ADDITIONAL SAMPLE DATA
SAMPLE OF _____ SHOWS
_____ PIECES BEYOND

REMARKS: _____

Figure 1—**Lot Plot for Plate I—Type 1**

II. THE SOLUTION

The solution developed was to prepare a frequency histogram of the variable characteristic from 50 pieces selected at random from the lot, making certain that the sensitivity of the gaging will result in a minimum of seven cells. The acceptance decision is based on whether the limits for individual values which will include almost all of them (approximately 99.7% if normal, and a high percent in the many other cases) are included, or whether either limit is excluded by the specification limits. Most of the time a visual inspection of the histogram will suffice to determine this decision without question. The Lot Plot form (Figure 1), however, has been designed to permit the inspector himself to compute the plus and minus three standard deviation limits (assuming normality) and the average value without resorting to a separate work sheet.

Here are the mechanics of inspection under the Lot Plot plan:

A. Getting a random sample of 50 parts.

1. If the material is received in an orderly manner, e.g. packages of a given number of items in each, assign a number to each item; box 1 would contain bolts 1 to 100, box 2 bolts 101 to 200, etc., for example.
2. Refer to a sample card for the lot size. This card contains 50 random numbers listed in numerical order, none of which exceeds the lot size. Cards are available on the job, having been made up in advance for convenient lot size increments. (A convenient way to get these numbers is to take the last few digits from a few columns of a 5 or 6 place table of logarithms.* Suppose the lot size is 1453 pieces. Sampling cards would be available for lot sizes of 1400 and 1500, and the latter would be used. It would have been constructed by taking, in pairs, the last two digits from each of two adjacent log table entries which, say, gave 2427, 9308, 1274, 0531, 1529, 5212, 1170, etc. Numbers above 1500 are discarded, so 1274, 531, and 1170 would be three of the 50 numbers of the sampling card. (Any number between 1453 and 1500 that might be on this card will not be represented in the particular lot, and these few can be selected from the lot by any other reasonable scheme.) The 50 parts corresponding by their position in the packages to these numbers are pulled out for inspection.

*Although this is a practical source of such numbers, a more correct source (tested by several means for randomness) is "Tables of Random Sampling Numbers", M. G. Kendall, and B. Babington Smith, Cambridge University Press, 51 Madison Avenue, New York, N. Y.

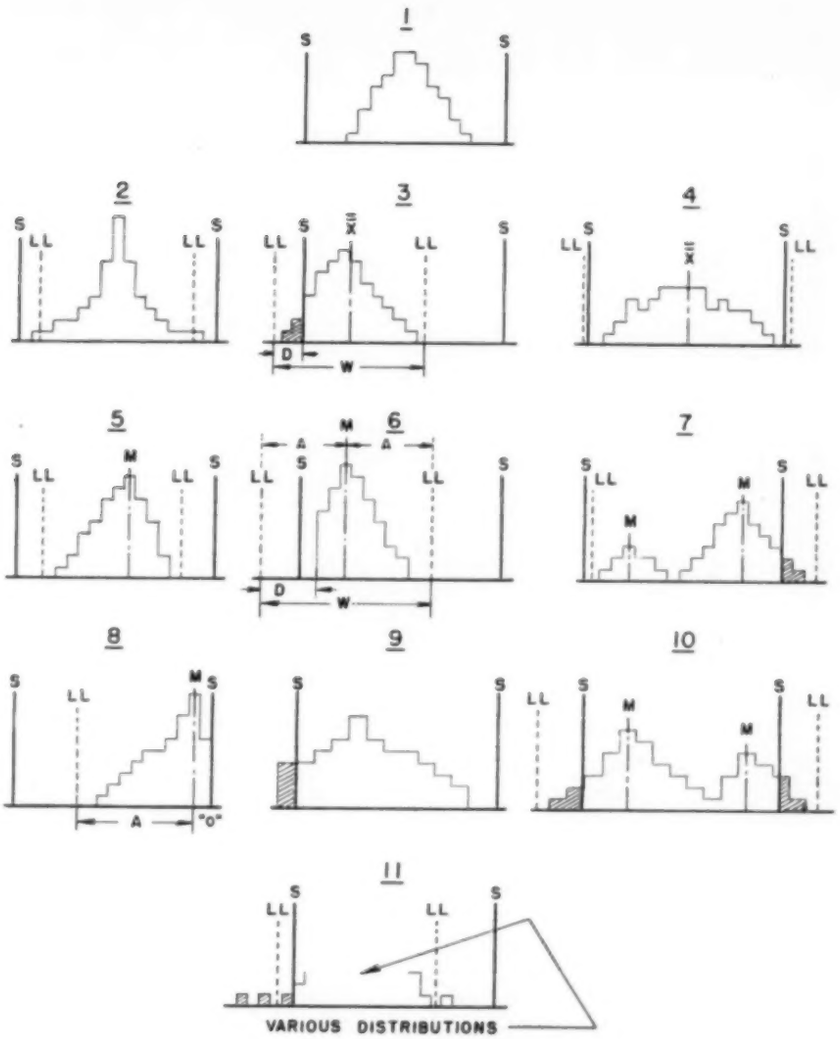


Plate I—**Eleven Typical Types of Lot Plots**

LEGEND

S = specification limit; LL = lot limit.

$\bar{X}$ = ave. of subgroup averages; M = mode.

"O" = zero, "full indicator reading."

A = distance in cells from mode to lot limit from Charts C_1 or C_2.

D = distance in cells from spec. limit or cut-off point, as case may be, to lot limit.

W = base width, or distance in cells from one lot limit to the other.

---

3. If the material, instead, is received in a jumbled mixture in a container, it should all be spread out in such a manner that each piece is equally likely to be selected. A representative 50 is then picked for the check. Variations on this method to increase its effectiveness, are grouping the items into divisions of 100's or 1000's by weight before employing a sampling card or, if the lot is not too large, counting successive items as they are picked out of the container until each number on the card is reached.

B. Setting the Gage (indicator type comparator) and filling in the Plot.

1. Select any 5 pieces from the sample of 50.
   a. Run the 5 pieces through the gage, and set the zero of the gage at about the average size of the 5 sizes.
   b. Check zero setting for actual size vs. a standard (size blocks, etc.) and adjust zero reading the portion of one division necessary to give a specific figure or reading.
   c. Enter this size in extreme left column of plot opposite the zero cell.
2. Determine the range (difference between highest and lowest values) of the 5 readings.
   a. Multiply this range by two.
   b. If this value is between 7 and 16 cells, the cell width selected is adequate. If the value is not as above, increase or decrease cell width as required.

Corresponding steps which can be taken with micrometers, thermometers, stop watches, hardness testers, tensile machines, or any other device for measuring by variables will be obvious to the reader.

3. Now enter remaining actual sizes in the left hand column by increasing and decreasing from the selected zero value in units of cell width as indicated by the plus and minus signs in the second column.
4. Enter readings obtained on first 5 pieces, each as falling between an adjacent pair of listed sizes, by marking a 1 in the proper squares to the right of the second column. These values and succeeding readings will be in terms of plus or minus so many cells from zero value. No further attention need be given actual sizes.
   a. Enter sum of first 5 readings, using the printed cell numbers that are one-half a cell diagonally, up to the left,* being careful to consider plus and minus values, in the SUM column in the right hand tabulation, and also enter the range in the RANGE column.
   b. Calculate average for AVG. column by multiplying the sum by two and moving decimal point one place to the left. Enter in column being sure to maintain proper sign.
5. Repeat (4) for each group of 5 until 50 pieces are complete, using five 2's to indicate second sample readings, 3's for the third, etc.

*Considerable objection has been experienced in the field to the staggered scale employed on the Lot Plot forms illustrated. The author feels the basic purpose of this arrangement is fundamentally sound, but recognizes that the situation can be misunderstood. New Lot Plot forms are being designed (and will be available shortly after this article goes to press) which will meet this objection and still preserve the basic thinking behind the original arrangement of cell marks.

C. *Calculation of Limits.*

1. Total up AVG. column by first eliminating all equal plus and minus values, then adding all remaining plus values, and all minus values and finding the difference. Enter this in space provided using proper sign.
2. Add all range values to find total.
3. Determine $\bar{\bar{X}}$ and $\bar{R}$ values (grand average and average range, respectively) by dividing appropriate total by the number of samples of 5 used (i.e. for a total sample of 50 divide by 10).
   a. Enter the $\bar{\bar{X}}$ value at right hand edge of Plot area in space provided by counting, plus or minus the value indicated, starting halfway between the zero and —1 lines.
   b. Draw a short line to indicate this point and mark it $\bar{\bar{X}}$.
4. In the space under the $\bar{R}$ value enter a value equal to 0.3 times $\bar{R}$, and add the two together, to arrive at the 3σ value. This comes from $3\bar{R}/d_2$ which gives $(3/2.326)\bar{R}$ or $1.29\bar{R}$).
   a. Using this value, count from the $\bar{\bar{X}}$ point the equivalent number of cells in both directions and mark each point.
   b. The plus point will be the upper lot limit (ULL) and the minus point will be the lower lot limit (LLL).

III. HOW TO HANDLE LOT PLOTS

1. *Normal shaped distribution.* Distribution included well within specification limits. No $\bar{\bar{X}}$,$\bar{R}$ need be computed. Accept. See Note (a) below.
2. *Sharp-peaked, reasonably symmetrical distribution with long tails.* Compute lot limits. When a lot limit cuts off any part of a distribution, use proper attribute sampling plan at the specification limits as per Section IV, E.
3. *Normal-shaped distribution intersected by a specification limit.* Use distance D and base width W in cells; refer to Chart A to find percentage of material beyond specifications. Salvage.*
4. *Flat type, reasonably symmetrical distribution.* Compute lot limits. If lot limits are within specifications, accept. If not, proceed as per (3) above. Result here will always be somewhat conservative, that is, the lot limits so calculated could be narrower and still include practically all cases.
5. *Unimodal, non-symmetrical distribution.* Use Table B and Chart C_1 or C_2 to find lot limits (see Section IV, A). If lot limits are within specifications, accept. If not, proceed as per (3) above, but remember that the Chart A percentage applies to *twice* that portion of the lot which is proportional to the part of the sample on the corresponding side of the mode. Thus, for example, for the top of Figure 15 (p. 31) we calculate for one-half of a normal curve consisting of 15 cases in the one tail, or 30 altogether in such a total curve. The percent of these 30 cases beyond the high limit is 5% (from Chart A), i.e. 1.5 cases should be expected out on the side. Thus for the odd distribution this figures 1.5 per lot of 50, or 3% as recorded on Figure 15 (or see Section VIII, J).
6. *Apparently normal distribution with one tail cut off.* Compute lot limit for the complete half of distribution using Table B and Chart C_1 or C_2. Establish other lot limit at equal distance A from the mode. If lot limits are within specifications, accept. If not, use proper attribute sampling per Section IV, E at the cut-off end value. Note that attribute sampling is not suggested at the specification values because sometimes the cut-off end is a cell or two beyond the specification limit (see illustration for Type 9). Proceed as per last sentence of (5) above at complete end if necessary.
7. *Two or more distributions indicated.* Take additional sample if necessary or change cell intervals where required to give sufficient data on all distributions. Compute lot limits for ends of distributions most affected by the specifications, using exterior modes and Table B with Chart C_1 or C_2. If limits fall within specifications, accept. If not, salvage. Remember Chart A percentages apply to *twice* the portion of the lot that is proportional to that part of the sample (from mode outward) comprising the particular distribution used, and must be adjusted to give the proportion of the total sample.
8. *"Half" or "Half-plus" distributions* such as are formed by concentricity, squareness, and parallelism specifications. Compute lot limit using Table B and Chart

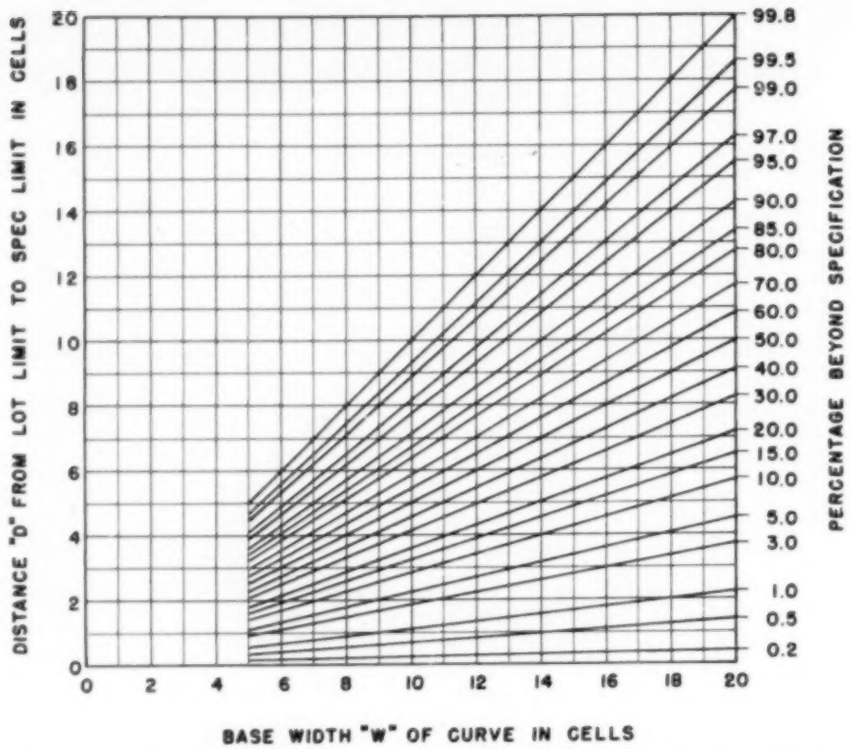


Chart A—**Percentage of a Normal Curve Beyond a Specification Limit**

*The term "salvage" denotes that disposition of the lot is to be determined by other considerations described later.

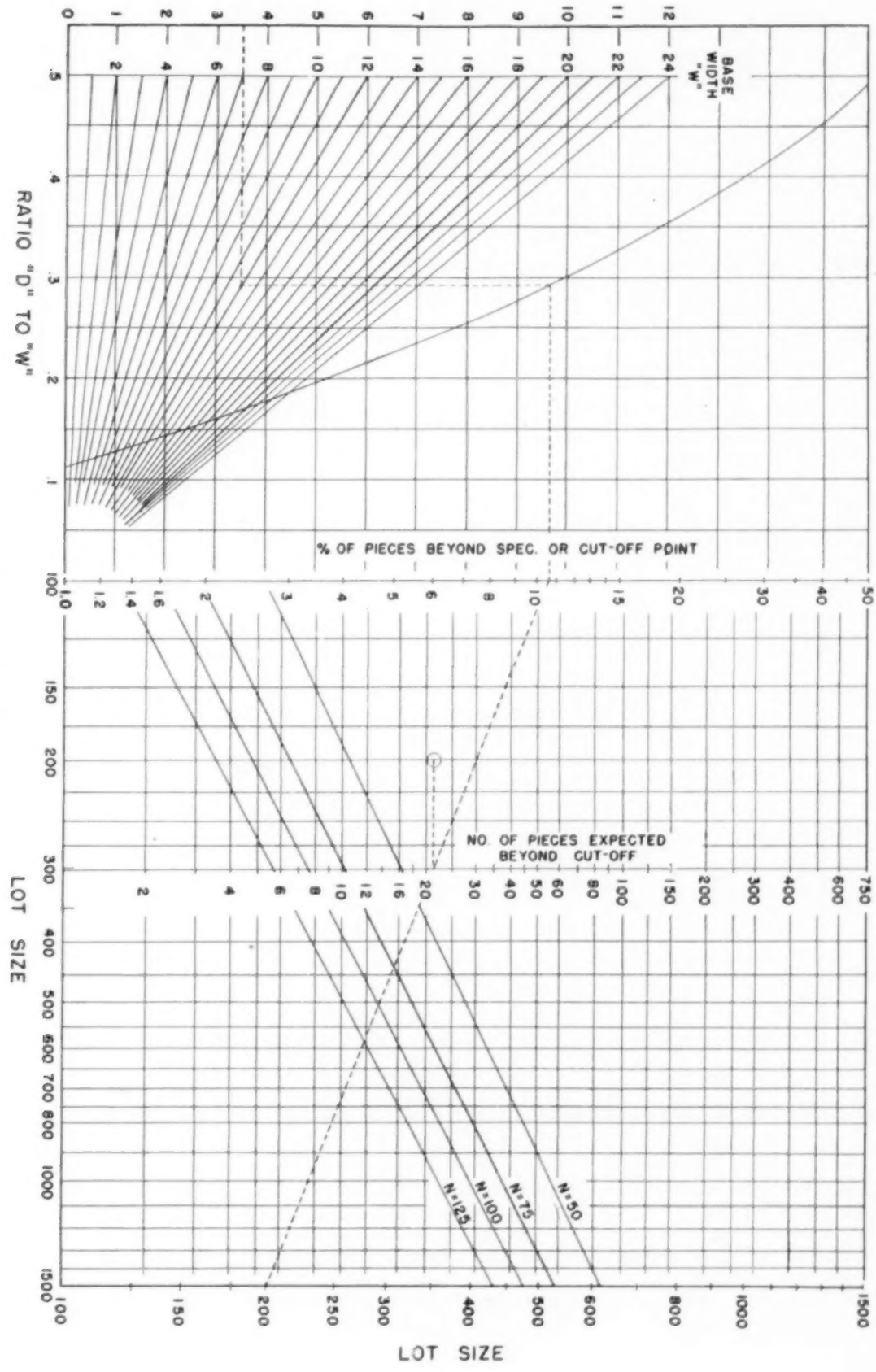


Chart A—Extended

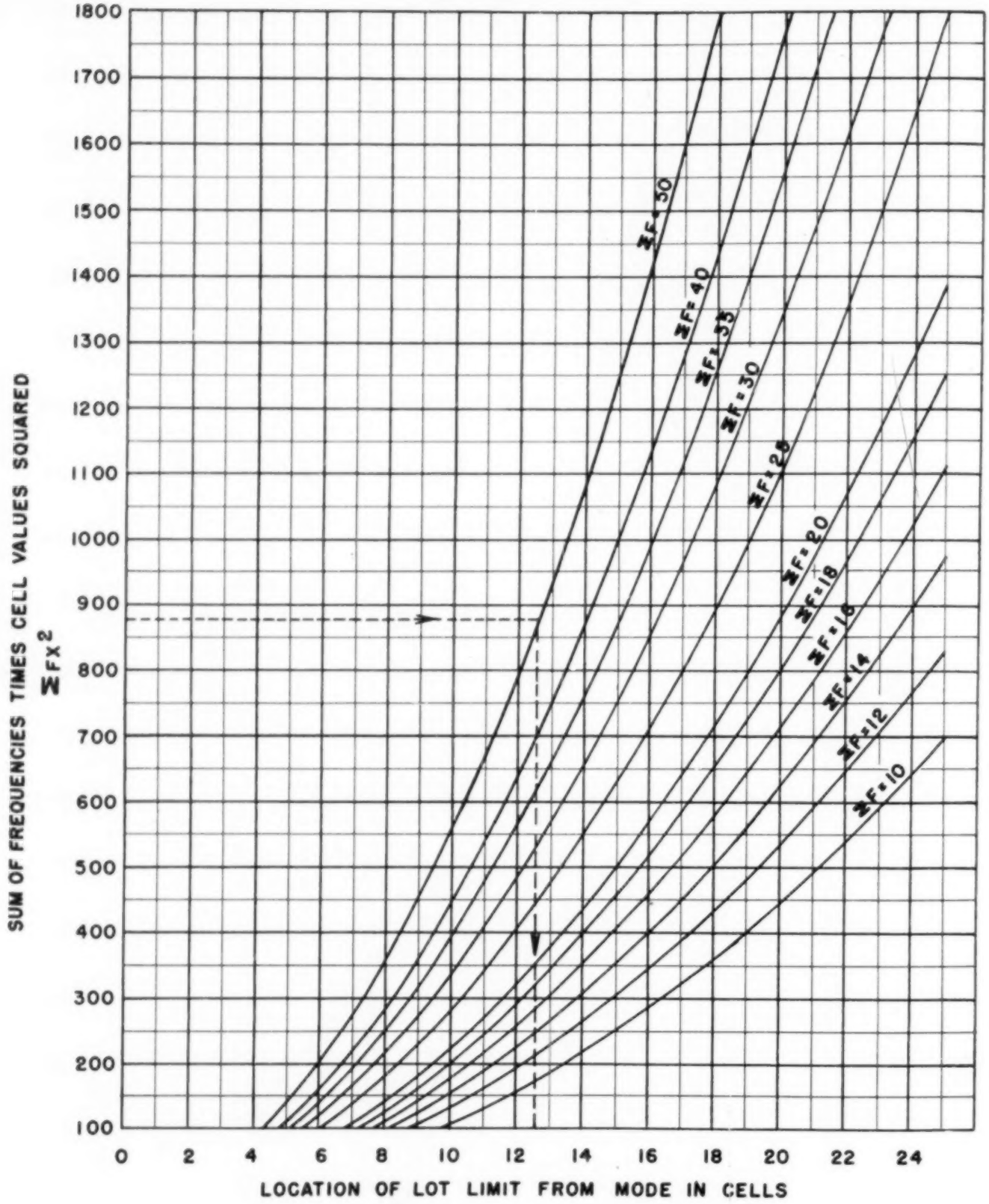


Chart C_1—**Curves for Finding Lot Limits, $\Sigma FX' \geq 100$**

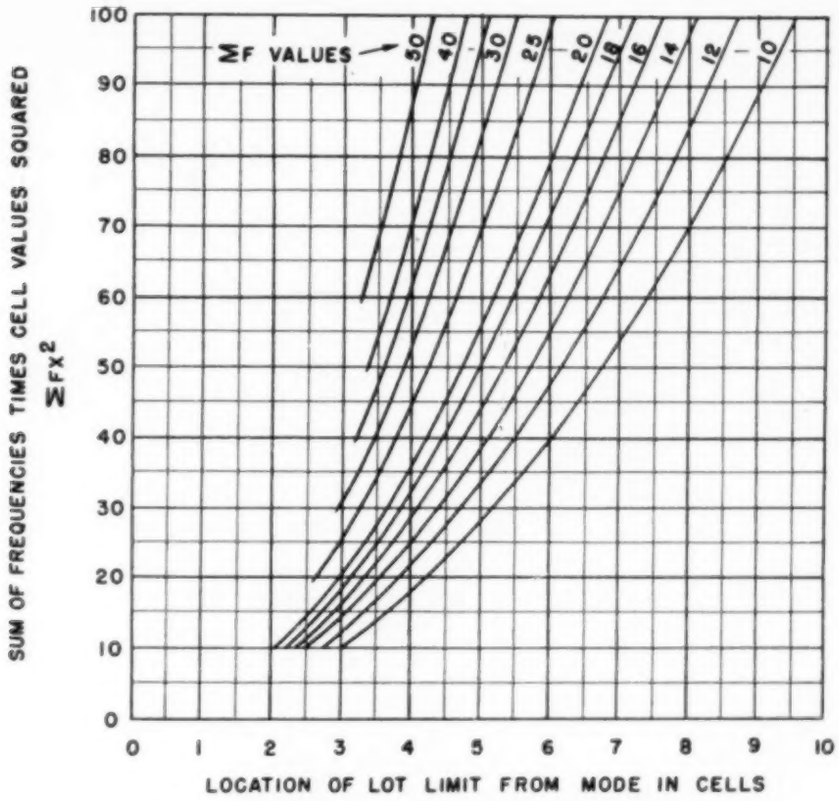


Chart C_2—**Curves for Finding Lot Limits, $\Sigma FX^2 \leq 100$**

C_1 or C_2. If within specifications, accept. If not, salvage, estimating from Chart A percentage of parts in error, from *twice* the portion of the lot at that side of the mode.

9. *Distribution with both ends cut off.* Use proper attribute sampling plans at the *cut-off points* per Section IV, E. If no pieces have been found beyond specifications, accept if attribute plan passes. If beyond specification parts are found, salvage for further instructions when attribute plan passes. See Note (b) below.
10. *Two or more overlapping distributions indicated;* a variation of (7). Proceed as in (7).
11. *"Stray" pieces occurring beyond lot limits.* Determine from Chart D the most likely number of strays in the lot, then add, in the direction away from the distribution, the number of cells shown by Chart E from the stray closest to the distribution to establish the stray probability point.* If this point is within specifications, accept. If not, salvage.

Note (a): Type 1 can also represent any distribution that is entirely well within specification limits (provided one watches for the Type 11 situation). Distributions which would represent borderline decisions, because of their position or extent of the lot limits with respect to specification limits, are the ones which require the determination of the lot limit positions. Also in this category are the distributions which extend beyond specification limits, so that estimates of number of defective pieces and the extent to which they are defective can be made for the determination of the disposition of the lot by the salvage board.

Note (b): When a Lot Plot shows a condition similar to that indicated in Type 9, but exaggerated to the point where the picture may be more or less flattened and a number of readings are beyond the specification limit, a distribution to fit one of the standard types can sometimes be made by increasing the cell width and replotting, but do not go under the required minimum of seven cells.

*The stray probability point is that point at which another stray may be rarely expected.

IV. HOW TO HANDLE NON-NORMAL PLOTS THAT ARE BORDERLINE OR THAT CONTAIN DEFECTIVES

A. If the distribution of 50 is skewed, each side extending out from the mode can be treated as half of a symmetrical distribution (left-hand side of Figure 2) and the inspector determines a right-side and a left-side (if both are borderline, or beyond the specification limit) three standard deviation limit as follows:
Set $X_M = 0$, and assign the square of cell numbers to succeeding cells such as 1, 4, 9, 16, 25, etc. (Figure 3). Multiply each by the F of the corresponding cell (use ½ of the frequency of the mode cell), sum up the F and FX^2 columns separately for each side of the distribution, and enter the ordinate of Chart C_1 or C_2. Read over to the curve ΣF (which is the term, $N_M + \frac{1}{2}N_M$ for example) and the abscissa gives the position of the lot limit.

B. If in your judgment the distribution appears to be multimodal, the procedure is the same, but only the values from the most exterior mode or modes need be considered to form the symmetrical or shadow pattern. Here, quite often, the distribution may have to consist of approximately 75 to 100 pieces to get sufficient readings from the mode out.

C. If the specification is a concentricity, parallelism, or squareness requirement, the distribution will inherently be "halved", and again only the values to one side of the mode need to be considered.

D. If the distribution is noticeably flat-topped and drops abruptly at the ends, which is a fairly common departure from normality, then the lot limits calculated on the assumption of normality are too conservative. Hence if limits calculated from Table B and Chart C_1 or C_2 are approximately at the specifications or even a trifle outside with no actual pieces near the lot limits so calculated, then the lot can be accepted safely in this case. This situation eliminates the borderline nature of the distribution. On the other hand when, as in Type 2, there is quite a bunching of frequencies near the middle of a balanced distribution with pieces on both sides tapering rather far away from the mode, the lot limits will not be wide enough apart from the $\overline{R}$ calculation. We then resort to an appropriate attribute sampling plan if the lot limits calculated from $\overline{R}$ are even close to the specifications. Fortunately this is

a rather rare case.

E. Occasionally a Lot Plot will have one or more sampled parts beyond lot limits. Since the predictive value of the lot limits is inaccurate for this condition, a special attribute sampling plan having an AOQL of 4% (the selection of 4% is explained in paragraph H) was computed to utilize the data obtained from the 50 pieces already checked.

This plan specifies that the lot is considered acceptable if no more than three pieces of the 50 are beyond specification. If more than three are present, the material is screened 100% at the specification in question. The range of operating characteristic curves and average outgoing quality curves is presented in Figures 4 and 5. This special supplementary attribute plan applies whenever the dimension in question will mate with another dimension at assembly. When the function of the specification is a structural one (wall thickness, stress relieving radius, hardness test, etc.) a standard Dodge-Romig single sampling AOQL 0.1% plan is used.*

F. Now and then a distribution shows definite evidence of the vendor having screened the lot at a specification limit, or of a process limitation prohibiting sizes beyond a certain point. This condition is represented by chopped-off plots at one or both ends, sometimes right in the region of the specification limit (Type 6 or 9, Figure 3). Here the question to be settled, after 50 pieces have been checked, is "Did the process have this characteristic, did the vendor attempt screening, or did just the chance selection of 50 from the lot result in only the appearance of screening?" The family of lines of Chart A—Extended** can settle this with 95% assurance.

From probability considerations, the line marked "50" represents the combination of lot size and of the number of pieces expected in the entire lot beyond

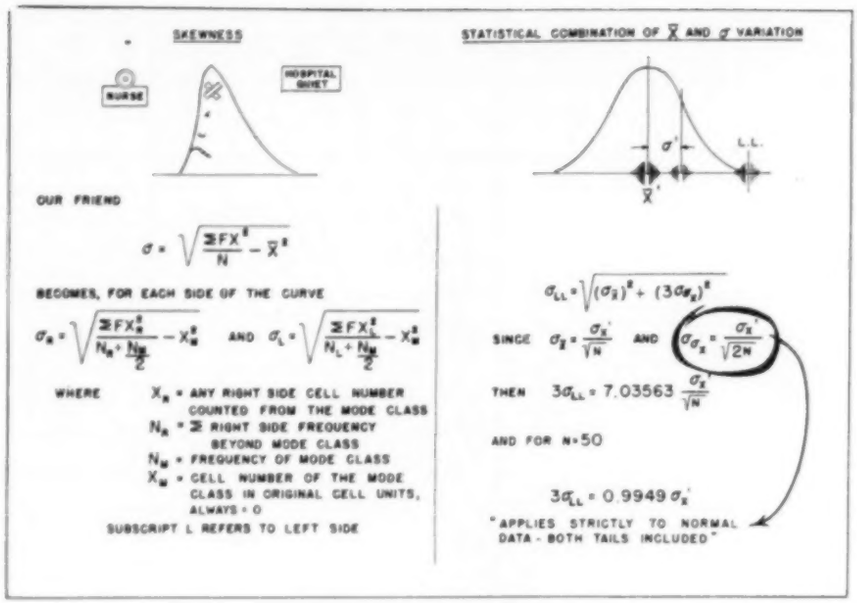


Figure 2—**Formulae**

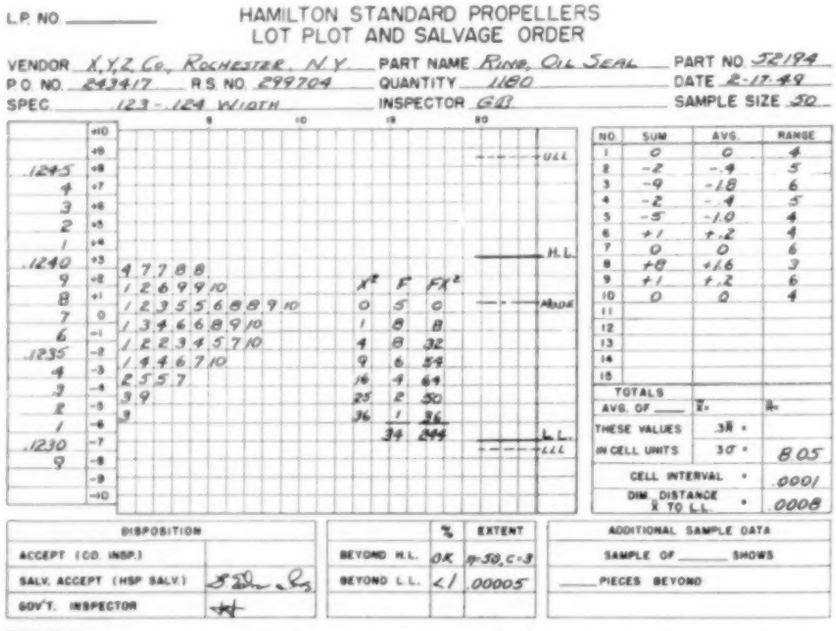


Figure 3—**Lot Plot for Plate I—Types 6 and 9**

the chopped-off point, obtained from establishing the lot limit at distance A from the mode (see Type 6) that would result in a 95% assurance that at least one such piece would be found in the sample of 50. If the combination of lot size and number of expected pieces results in a point in the region above the line marked "50", it can be concluded that the screening by the vendor did take place. On the other hand, if the point lies below the 50 line, then additional pieces are to be inspected so as to bring the total sample size up to the indicated size, and the total sample must contain no parts beyond the chopped-off value.

The left half of Chart A—Extended is the same material as Chart A, except that its form is different and the range of "Percentage Beyond Specification" is reduced in the extended version. An objection to using the extended version is that all that is really settled with 95% assurance is that the screening did

*"Sampling Inspection Tables" Single and Double Sampling by H. F. Dodge—H. G. Romig—John Wiley & Sons, Inc., N.Y.

**Poisson's Exponential Binomial Limit was used for N greater than 1,000, while for N less than 1,000 we used the exact combinatorial formula, utilizing $C(n,r) = n!/r!(n-r)!$ where $C(n,r)$ is the number of combinations of n things taken r at a time.

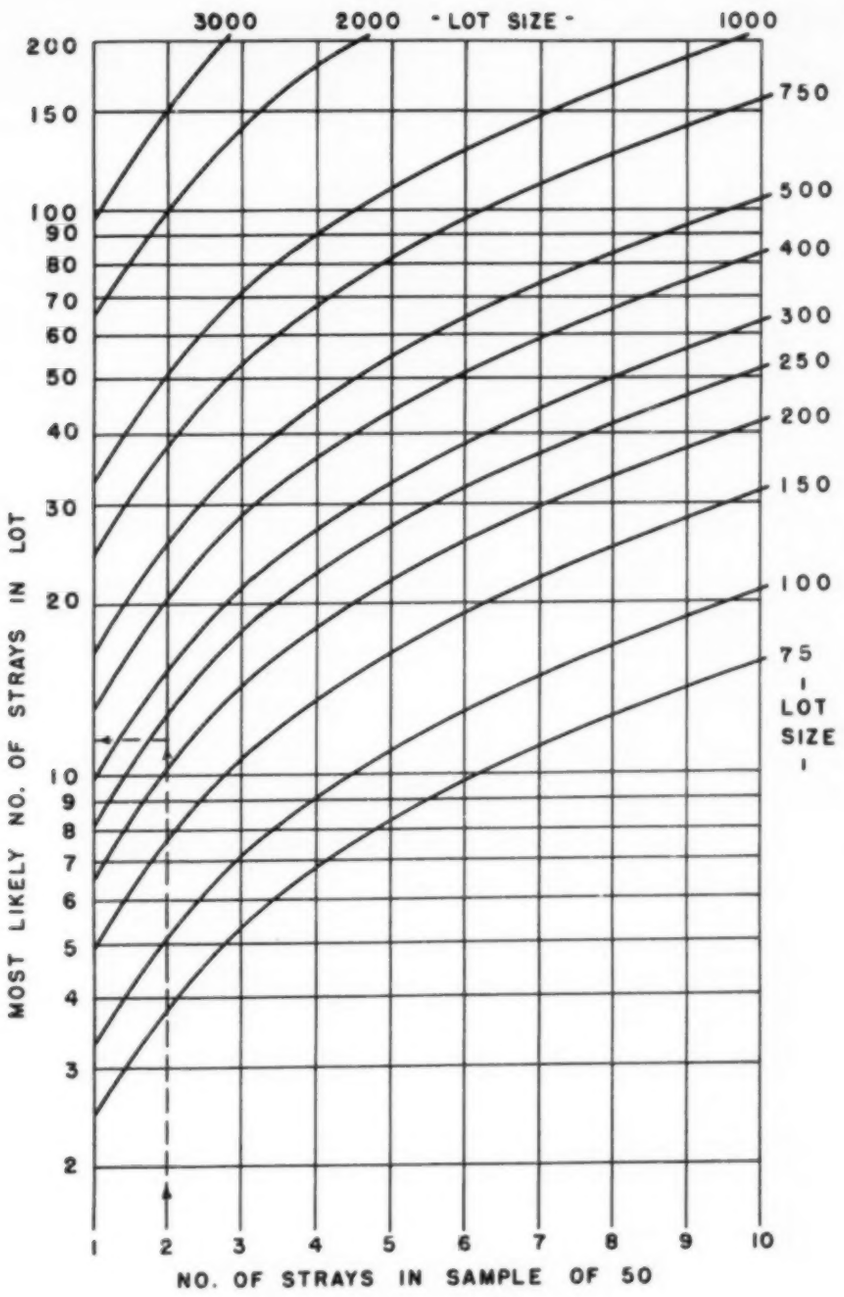


Chart D—**Stray Quantity Chart**

take place. There is no indication as to how successful or complete it might have been. Presumably it was subject, to a certain degree, to the ineffectiveness of 100% inspection. If the cut-off situation is "known" to be caused by a physical limitation of the process, this 100% inspection weakness would not apply, and the chart *would* give 95% assurance to the word "known".

In our aircraft work we are using Chart A. When a mating dimension is involved, the n = 50, c = 3 plan takes adequate care of the cut-off plot situation. When the specification is structural, we prefer to use the larger sample size of the 0.1% AOQL plan as against knowing with 95% assurance that some screening did take place. Other industries using our Lot Plot plan, however, have found useful the extended chart, and it is accordingly presented here.

G. When, from the position of the lot limit, it is determined that a certain percentage of a lot is beyond a specification limit, the disposition of the material is to present it for consideration that leads to an ultimate disposition by a salvage board. The number of pieces expected beyond specification and the extent of the error (the dimensional location of the lot limit) are the facts upon which the salvage board makes its disposition. Probability mathematics give the board additional help in formulating an intelligent decision whenever the specification is one that will be involved with another on the mating part to give a resultant tight fit or clearance. Here, in terms of the percentage that the error is of the mating part tolerance, a table gives the probability of random assemblies meeting the assembled requirements, or a numerical measure of their degree of interchangeability. (See Figure 6). This table also gives the percentage of assemblies that will have an assembly fit not exceeding ½ the extreme part error. Two assumptions are made: a normal distribution for the mating part, and six standard deviations equal its tolerance, thus centering the distribution. The first is sometimes not valid, but often this is more than offset by the distribution being narrower than the allowable tolerance and being near center. At any rate, having Lot Plots on file of the mating dimension for such reference purposes by the salvage board is the best way to employ this principle. Here the Nomogram, Figure 6A (addition of independent variances), can be of more specific use. Two or more 6σ spreads (natural component tolerances) can be added statistically by connecting the right sides of the outer lines of the Nomogram with a straight edge, then pairing this resultant with the next tolerance, etc., each resultant sum always being read on the right side of the center scale. When either component tolerance exceeds 5 units, use the left side of each line instead of the right. When 20 units are exceeded, return to the right side of each line calling 20, 2.0, etc.

H. Certain specifications can only be checked by attributes, (magnaflux tests, small diameter internal threads, etc.), so AOQL values for standard sampling plans are determined that will be equivalent to the 0.15% of the lot in a

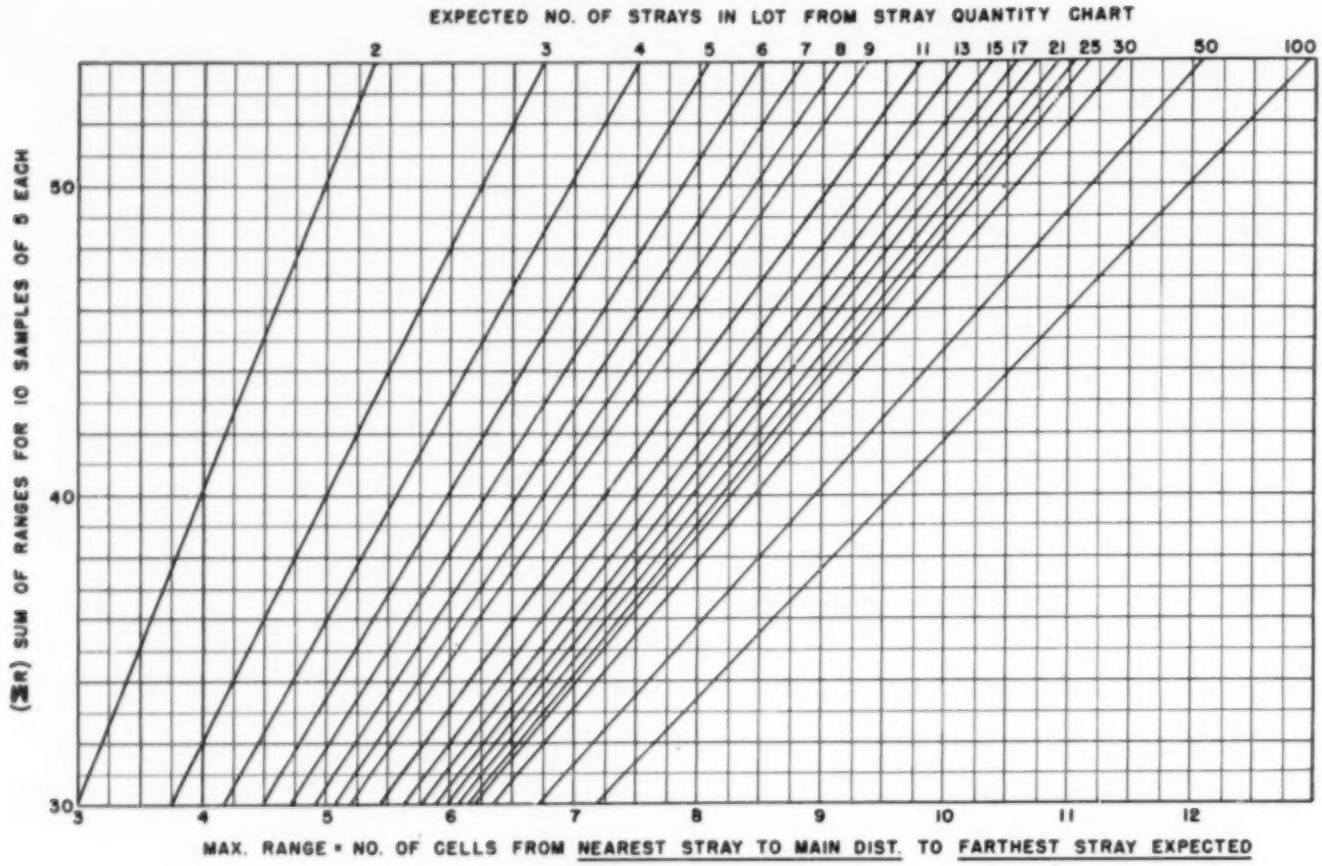

EXPECTED NO. OF STRAYS IN LOT FROM STRAY QUANTITY CHART
2 3 4 5 6 7 8 9 11 13 15 17 21 25 30 50 100
(ΣR) SUM OF RANGES FOR 10 SAMPLES OF 5 EACH
50
40
30
3 4 5 6 7 8 9 10 11 12
MAX. RANGE = NO. OF CELLS FROM NEAREST STRAY TO MAIN DIST. TO FARTHEST STRAY EXPECTED

Chart E—**Stray Probability Chart**

normal distribution that can occur beyond each 3σ limit of the variables pattern. When the specification has no mating requirement, i. e., is structural, an AOQL of 0.10% is used. For mating specifications, AOQL's of 4% are employed, which results in a maximum probability of 0.16% that two defectives will be chosen to be mated by chance. For additional discussion on this matter, the reader is referred to Case History VIII B ahead. It should be understood that while in rare cases the actual experience may be worse than 0.16%, the long term limiting probability levels off at some value less than this figure.

I. For the effective administration of the receiving inspection section, detailed instructions have been prepared for the use of the foreman and the inspection leadmen. In addition to the material already covered here, this instructional procedure covers three other significant phases of the inspection plan: splitting lots of attribute sampled material to have increased assurance of meeting AOQL's, reduced variable sampling in the form of a "Continuous Lot Plot" plan when past data show satisfactory evidence of acceptable statistical control, and obtaining quality improvement through making results known to vendors. This matter of splitting lots is a method of combatting the problem of rapid turnover of parts in the storeroom. Customers may get material that is more defective

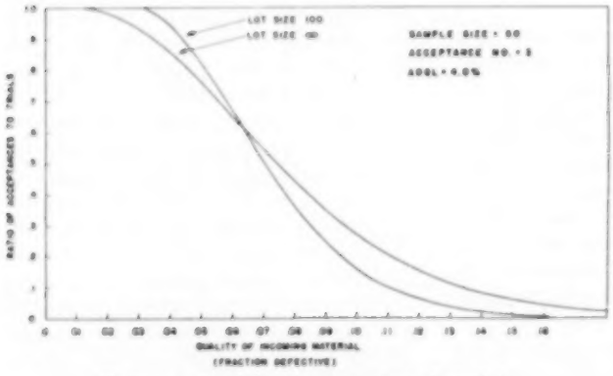


Figure 4—**OC Curves for Special Attribute Sampling Plan**

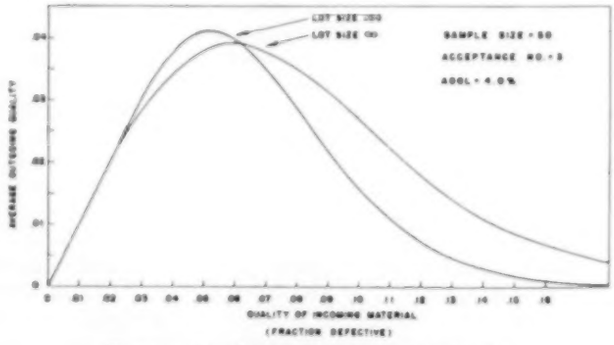
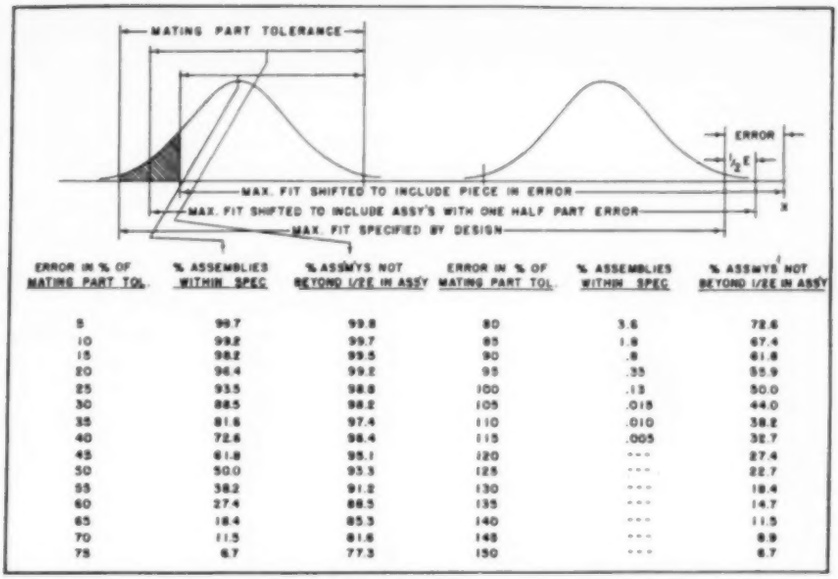


Figure 5—**AOQ Curves for Special Attribute Sampling Plan**


MATING PART TOLERANCE
ERROR
½ E
MAX. FIT SHIFTED TO INCLUDE PIECE IN ERROR
MAX. FIT SHIFTED TO INCLUDE ASSY'S WITH ONE HALF PART ERROR
MAX. FIT SPECIFIED BY DESIGN

ERROR IN % OF MATING PART TOL.	% ASSEMBLIES WITHIN SPEC	% ASSMYS NOT BEYOND I/EE IN ASSY	ERROR IN % OF MATING PART TOL.	% ASSEMBLIES WITHIN SPEC	% ASSMYS NOT BEYOND I/EE IN ASSY
5	99.7	99.8	80	3.6	72.6
10	99.2	99.7	85	1.8	67.4
15	98.2	99.5	90	.8	61.8
20	96.4	99.2	95	.35	55.9
25	93.5	98.8	100	.13	50.0
30	88.5	98.2	105	.015	44.0
35	81.6	97.4	110	.010	38.2
40	72.6	96.4	115	.005	32.7
45	61.8	95.1	120	---	27.4
50	50.0	93.3	125	---	22.7
55	38.2	91.2	130	---	18.4
60	27.4	88.5	135	---	14.7
65	18.4	85.3	140	---	11.5
70	11.5	81.6	145	---	8.9
75	6.7	77.3	150	---	6.7

Figure 6—**Probable Assembly Deviation**

than the AOQL—material that has not been stored long enough to be diluted with better material that got that way as a result of screening. Lots are therefore split into smaller lots for sampling so that at any time the storeroom will contain a mixture of several separate samplings. The Continuous Lot Plot is our adaptation, by variables, of Mr. H. F. Dodge's sampling plan (by attributes) for continuous production,* details of which are not included in this paper.

Table B—**Chart for FX′ Values**

X	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
F \ X²	1	4	9	16	25	36	49	64	81	100	121	144	169	196	225
1	1	4	9	16	25	36	49	64	81	100	121	144	169	196	225
2	2	8	18	32	50	72	98	128	162	200	242	288	338	392	450
3	3	12	27	48	75	108	147	192	243	300	363	432	507	588	675
4	4	16	36	64	100	144	196	256	324	400	484	576	676	784	900
5	5	20	45	80	125	180	245	320	405	500	605	720	845	980	1125
6	6	24	54	96	150	216	294	384	486	600	726	864	1014	1176	1350
7	7	28	63	112	175	252	343	448	567	700	847	1008	1183	1372	1575
8	8	32	72	128	200	288	392	512	648	800	968	1152	1352	1568	1800
9	9	36	81	144	225	324	441	576	729	900	1089	1296	1521	1764	2025
10	10	40	90	160	250	360	490	640	810	1000	1210	1440	1690	1960	2250
11	11	44	99	176	275	396	539	704	891	1100	1331	1584	1859	2156	2475
12	12	48	108	192	300	432	588	768	972	1200	1452	1728	2028	2352	2700
13	13	52	117	208	325	468	637	832	1053	1300	1573	1872	2197	2548	2925
14	14	56	126	224	350	504	686	896	1134	1400	1694	2016	2366	2744	3150
15	15	60	135	240	375	540	735	960	1215	1500	1815	2160	2535	2940	3375
16	16	64	144	256	400	576	784	1024	1296	1600	1936	2304	2704	3136	3600
17	17	68	153	272	425	612	833	1088	1377	1700	2057	2448	2873	3332	3825
18	18	72	162	288	450	648	882	1152	1458	1800	2178	2592	3042	3528	4050
19	19	76	171	304	475	684	931	1216	1539	1900	2299	2736	3211	3724	4275
20	20	80	180	320	500	720	980	1280	1620	2000	2420	2880	3380	3920	4500
21	21	84	189	336	525	756	1029	1344	1701	2100	2541	3024	3549	4116	4725
22	22	88	198	352	550	792	1078	1408	1782	2200	2662	3168	3718	4312	4950
23	23	92	207	368	575	828	1127	1472	1863	2300	2783	3312	3887	4508	5175
24	24	96	216	384	600	864	1176	1536	1944	2400	2904	3456	4056	4704	5400
25	25	100	225	400	625	900	1225	1600	2025	2500	3025	3600	4225	4900	5625

V. HOW TO HANDLE STRAYS

That stray or freak piece lurking in certain lots presents a problem to any inspection plan. It is the odd piece or two, of a size or other quality characteristic that is completely foreign to the main distribution—a trial set-up piece left in the lot, the product of a sudden "breakdown" in the constant cause system of variables inherent to the process that might have been observed by the operator but the piece was not removed, the piece or pieces left in a bench drawer some time ago and added to a current lot, the result of a dishonest small periodic addition from a private scrap pile to good work, etc.

It is our experience that the majority of cases of a reported stray piece found by 100% inspection, when analyzed by a Lot Plot, turn out not to be a lone stray but rather one of a group of several other such defective pieces.

The very definition of a stray points up the severe inspector fatigue conditions present: a very large amount of good material has to be looked at before the stray is encountered. It is thus logical to believe that Lot Plot inspection actually has somewhat the better chance of finding strays, due to the tremendous reduction of inspector fatigue. For any Lot Plot, the operating characteristic probabilities of Figure 7 apply. For a lot size of 100 pieces containing 1 stray, no indication of its presence would be found 50% of the time; 2 strays out of 100 pieces will get by only 25% of the time. For much larger lot sizes, 1% strays will get by 61% of the time; 2% strays, 37%.

The lot tolerence fraction defective (fraction defective with a .10 probability of acceptance) varies from 3% to 4.7% depending upon the lot size. If screening is done when troublesome strays are found, the long run quantity of objectionable pieces will be held to an AOQL of 0.75%.

When a Lot Plot shows one or more strays, Type 11, Chart D will indicate, in terms of the number of

*H. F. Dodge, "A Sampling Plan for Continuous Production", *The Annals of Mathematical Statistics*, Vol. XIV, No. 3, September 1943—pages 264-279, or *Industrial Quality Control*, Nov. 1947, page 5.

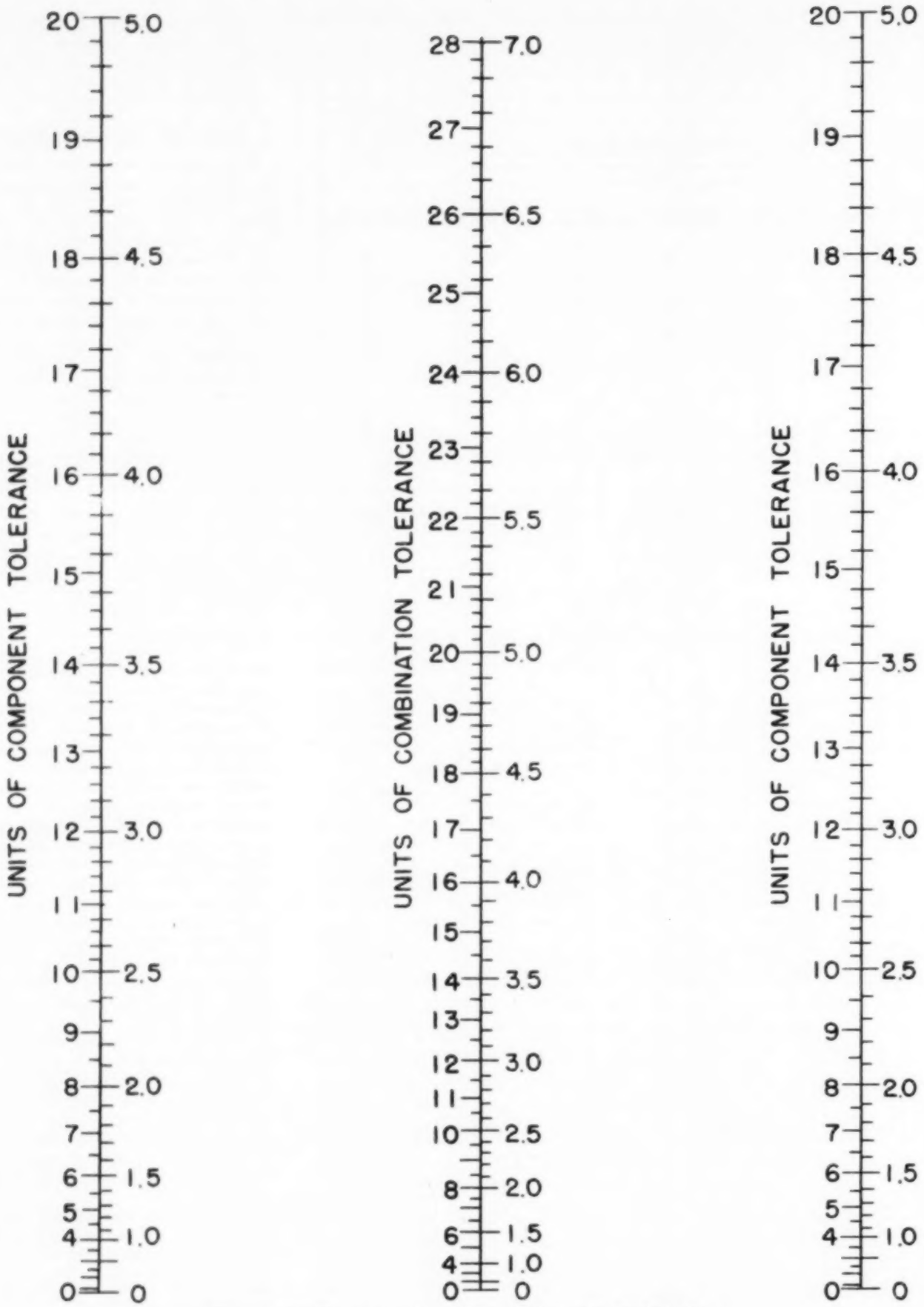


Figure 6A—**Nomogram for Adding Tolerances Statistically**

strays found and the lot size, the most likely number or the "expected number of strays in the lot". Chart E transforms this expected number, along with the sum of the ranges found in the Lot Plot, to the number of cells to count out in an adverse direction (away from the $\bar{\bar{X}}$ of the distribution) from the only stray, or from the one nearest to the distribution, to get to the worst other stray that might rather infrequently be expected to lurk in the lot. This type of conservative estimate can aid the salvage board in determining whether a careful screening should be undertaken to look for some particular strays that would be really undesirable.

Chart D is derived from General L. E. Simon's chart for the inverse solution of the incomplete Beta-function ratio 0.5. Estimates are given such that in repeated use the estimates will be too large just as frequently as too small, subject to the assumption that prior to sampling one lot-fraction defective is as likely as another. Chart E is based on the reasoning that the best estimate of the dispersion of any strays is related to the assumption that they are random selections from a distribution having the same standard deviation as the main one found in the sample of 50, but having a different average value. Accordingly, the chart is computed to give the upper control limit (0.90 probability), for ranges of sample size equal to the expected number of strays, with an average range equal to that of the main distribution, but corrected for the sample size of the expected number of strays. The conservatism of using a 0.90 limit and of taking the range of strays in a direction away from the main distribution can sometimes be matched against the validity of the assumption just mentioned, when more than one stray is found in the sample of 50.

Another way to look at the stray problem, with even more conservatism in mind,* is to consider the following two statements which incidentally apply to any Lot Plot of 50 measurements, regardless of the shape of the distribution, (thus also fitting the stray situation):

A. 94% of population values exceed the least value (or less than greatest value) found, with probability of 0.95.

B. 90% of population values are included between least and greatest values found, with probability of 0.95.

The first statement will be the more applicable one, since it is expected that strays will usually be concerned with only one of the two specification limits.

*S. S. Wilks, "Sampling and Its Uncertainties"—Symposium on Usefulness and Limitations of Samples. A.S.T.M., Dec. 1948.

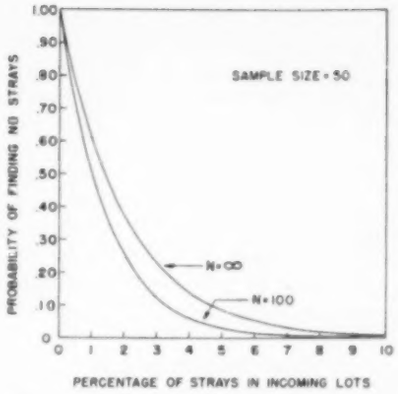


Figure 7—**OC Curves for Strays**

VI. HOW TO USE CHART A AND CHART A—EXTENDED

When the Lot Plot shows a lot limit beyond a specification and the sample either has pieces beyond the specification point as shown in Type 3, or has not as in Type 4, Chart A is used to complete the information required on the Lot Plot form:

A. Determine the number of cells to the nearest ½ cell between the specification and the lot limit, and also the number of cells between both lot limits (or multiply the 3σ value, already found, by 2) to get the base width "W".
   1. The first value is equal to "D", and is represented on the chart by the left-hand ordinate.
   2. The second value is equal to "W" and is represented by the abscissa.
   3. The right-hand curve numbers give directly the percent of the lot beyond specification, and it is entered on the Lot Plot in the proper space, in the central block at the bottom of the form. The value for EXTENT is simply the actual dimensional difference between the specification and the lot limit.

B. For the Type 6 distribution where the lot limit is beyond the specification, but the plot shows an abrupt cut-off appearance at the specification or at some point near the specification, to find the "missing" percentage of parts beyond the cut-off point, enter the *extended* chart with "D" (3½, for example) at left column and read horizontally to the right until a diagonal equal to "W" (W = 12, for example) is met. Then proceed up or down until the curved line is reached. At this point, again read horizontally to the right to the vertical scale marked "% of Pieces Beyond Spec. or Cut-off Point" (10.5% in this example). From this point on the chart, connect, by means of a straight edge, the percent value with the proper lot size (say 200) found on the extreme right hand scale. Where the straight edge crosses the middle scale will be found the expected number of pieces beyond the cut-off (in this example, 21). From this point on the middle scale proceed horizontally in the direction required to meet a vertical line extended from the proper point on the *bottom* lot size scale. The point will fall somewhere with respect to the diagonal sample size lines marked n = 50, 75, etc.
   1. If it is *above* 50, the sample was large enough and the Plot is acceptable.
   2. If it is below 50, but above 75, a sample in addition to the initial 50 must be taken to give a *total* sample size proportional to the point's location between 50 and 75. These additional pieces can be checked on a Go, No-Go basis and the Lot Plot accepted if no pieces are found beyond the cut-off. The "ADDITIONAL SAMPLE DATA" block should be filled in with results found.
   3. If one or more pieces are found, but within the Lot Limit, use Lot Limit (LL) for EXTENT; if outside LL use stray considerations.
   4. For points falling between 75-100, 100-125 handle as in B-2 above.
   5. For lot sizes larger than 1500, the chart can be further extended by using the relation n = 3N/M, where n is the required sample size for 95% assurance, N is lot size, and M is the expected number of pieces in the "cut-off" portion of the plot. (This comes from the Poisson approximation).

VII. HOW TO USE TABLE B AND CHART C

A. When a Lot Plot shows a condition similar to that of Types 5, 6, 7, 8 or 10, Section III, or has an irregular appearance with several peaks, Table B and Chart C_1 or C_2 are used to find the lot limits. Please note that the condition, Type 8, is characteristic of squareness, parallelism, and concentricity specifications so, even before any measurements are made, the inspector knows that the sums, averages, and ranges are not to be computed.

1. In the case of a Plot with several peaks the calculation should be made by using values falling outside of the two outermost peaks, which will be taken as the modes. It may be, and frequently is, necessary for this type of Plot to run an additional sample to provide a sufficient number of readings for the calculation of each limit.
2. When any peak is made up of two or more adjacent cells of equal length, the innermost cell should be selected as the mode.

B. Method.

1. When a mode cell has been determined, the value zero should be assigned to it, and numbers 1, 2, 3, etc. to successive cells outside of the mode. For a reduction in the amount of writing, the square of these numbers may be used directly and marked in a column to correspond with each cell (see Figure 3).
2. Write in frequencies as follows:
   a. Find the number of readings in the mode cell and divide by 2. If the number is uneven, add one to it before dividing by 2.
   b. Enter the result opposite the zero.
   c. Find the number of readings in the next cell designated 1, and enter this value alongside the 1, below or above that entered for the zero.
   d. Proceed in the same manner until all cells have been counted.
   e. Add these values to find total which is ΣF.
3. For each cell, mentally multiply the square of the cell values by the number of readings in that cell as entered in second column. Table B is a multiplication table giving such values in most cases, if one wishes.
   a. Enter Table B with cell value in top horizontal row (X) or this value squared in the second horizontal row (X^2).
   b. Read vertically down from this value to line showing number of readings in that cell as indicated in left hand vertical column marked F.
   c. Proceed in this manner for all cells, then add these findings to obtain a total.
4. Using Chart C_1 or C_2, enter with total just found in 3c above, at left hand scale marked ΣFX^2.
   a. Read horizontally until a curved line equal to the ΣF value found in 2e above is met. For values of ΣF not shown on chart, estimate its position by proportionally dividing distance between lines by eye.
   b. From the point where the two lines meet, read vertically down to find position of the lot limit. This value is given in number of cells. Therefore, starting at the midpoint of the mode (zero) *cell* count this number of cells on plot and enter *lot limit* at this point in the standard manner.

VIII. CASE HISTORIES ILLUSTRATED AND EXPLAINED

A. The initial use of Lot Plots will probably reveal only a few specifications running as well as the Type 1 situation — a normal shaped distribution included well within the specification limits (Figure 1). If such is the case and it is surprising to your organization, you should realize that by the use of proper cell widths, of a really representative or random sample, and by the elimination of flinching on the part of the inspector, you now have a picture of the condition of the lot that corresponds to the revelations brought to your eye by a microscope of the surface of an object.

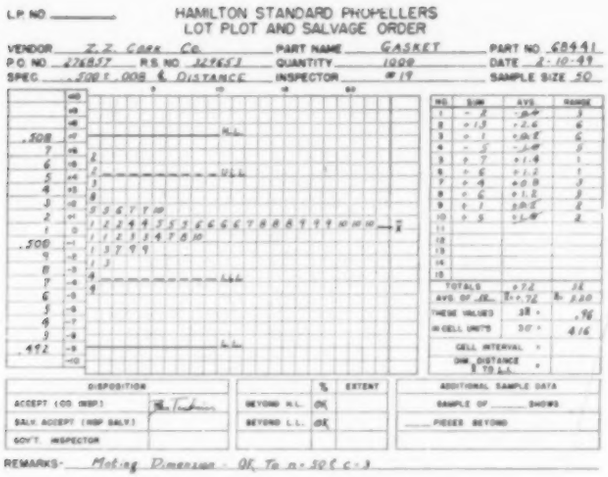
The correct use by the supplier of Shewhart type control charts, of course, will bring specification after specification into line to give the inspector Type 1 Lot Plots. It is our experience, and that of several other concerns, that sending a copy of each Lot Plot to the supplier of the material also often results in an increasing frequency of Type 1 situations. By far the majority of our Plots are now of this type.

While the sum, average, and range columns at the right of the plot form are filled in, in Figure 1, to illustrate the mechanics of computing the limits, in practice the inspector needs only to make an initial estimate of the situation after the first five pieces to save himself this work. Referring to Figure 1, note that subgroup number 1 had a range of seven with an average of +0.4. If plus and minus this range of the first five pieces from their average does not extend beyond specification limits, do not record each sum, average, and range for succeeding sub-groups. You could expect that the picture of 50 will usually develop into a near normal distribution with lot limits well within specification. In this example the estimate would show +7.4 to —6.6, with specification limits at +9.0 and —11.0.

Naturally, it is always necessary to continue to measure all the 50 pieces to see the completed picture. In a few cases the estimate will turn out to be a poor one with regard to the position or dispersion of the distribution, and here the inspector can pick out his sums, averages, and ranges from the sub-group numbers in the grid. When the plot turns out to be decidedly non-normal, treatment appropriate to the type into which it developed will be required. The three columns at the right of the form in such cases will still not be needed.

B. The long tails, which result in one or more pieces of the sample of 50 exceeding a lot limit, identify the Type 2 distribution (Figure 8). Here the lot limits serve only one purpose, that of calling attention to this type of deformation of the distribution; they obviously do not serve as estimates of the boundaries which include 99.7% of the lot.

Since the lot limits in this case do not have a sound predictive value, one has to resort to the pure attribute characteristics of the sample, being aided only qualitatively by the picture of the


HAMILTON STANDARD PROPELLERS
LOT PLOT AND SALVAGE ORDER

L.P. NO. _____

VENDOR Z. Z. Cork Co. PART NAME GASKET PART NO. 68441
P.O. NO. 276857 R.S. NO. 329651 QUANTITY 1000 DATE 2-10-49
SPEC. .500 ± .008 & DISTANCE INSPECTOR #19 SAMPLE SIZE 50

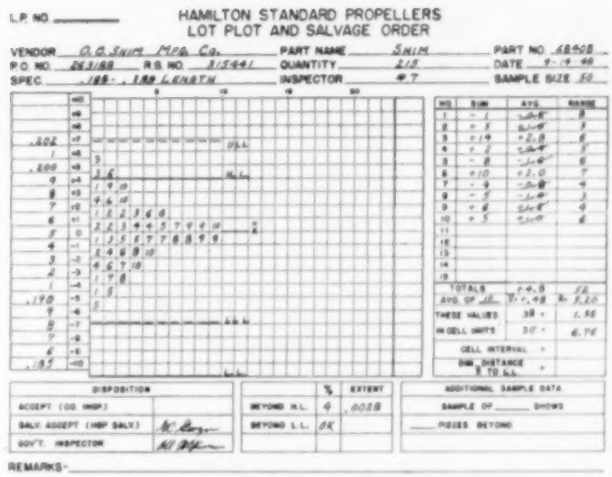
NO.	SUM	AVG.	RANGE
1	- 2	-.04	3
2	+ 13	+.26	6
3	- 1	-.02	5
4	- 5	-.10	5
5	+ 7	+.14	7
6	+ 5	+.10	5
7	- 4	-.08	3
8	+ 6	+.12	3
9	+ 1	+.02	2
10	+ 5	+.10	2
11			
12			
13			
14			
15			
TOTALS		+.72	38
AVG. OF 10		T=+.72	R= 3.80
THESE VALUES		38 ÷	.96
IN CELL UNITS		50 =	4.16
CELL INTERVAL		×	
DIM. DISTANCE X TO HL		+	

DISPOSITION			%	EXTENT
ACCEPT (CO. INSP.)		BEYOND H.L.	0%	
SALV. ACCEPT (HSP SALV.)		BEYOND L.L.	0%	
GOV'T. INSPECTOR				

ADDITIONAL SAMPLE DATA
SAMPLE OF _____ SHOWS
_____ PIECES BEYOND

REMARKS- Mating Dimension - OK To n = 50 & c = 3

Figure 8—**Lot Plot for Plate I—Type 2**


HAMILTON STANDARD PROPELLERS
LOT PLOT AND SALVAGE ORDER

L.P. NO. _____

VENDOR O. O. Smith Mfg. Co. PART NAME SHIM PART NO. 68908
P.O. NO. 263188 R.S. NO. 315441 QUANTITY 215 DATE 9-19-49
SPEC. .189 ± .180 LENGTH INSPECTOR #7 SAMPLE SIZE 50

NO.	SUM	AVG.	RANGE
1	- 1	-.02	8
2	+ 3	+.06	3
3	+ 14	+.28	6
4	+ 2	+.04	7
5	- 8	-.16	6
6	+ 10	+.20	7
7	- 4	-.08	4
8	- 5	-.10	3
9	+ 8	+.16	4
10	+ 5	+.10	6
11			
12			
13			
14			
15			
TOTALS		+4.0	58
AVG. OF 10		T=+.98	R= 5.80
THESE VALUES		38 ÷	1.55
IN CELL UNITS		50 =	6.75
CELL INTERVAL		×	
DIM. DISTANCE X TO HL		+	

DISPOSITION			%	EXTENT
ACCEPT (CO. INSP.)		BEYOND H.L.	4	.0028
SALV. ACCEPT (HSP SALV.)		BEYOND L.L.	0%	
GOV'T. INSPECTOR				

ADDITIONAL SAMPLE DATA
SAMPLE OF _____ SHOWS
_____ PIECES BEYOND

REMARKS-

Figure 9—**Lot Plot for Plate I—Type 3**

distribution. This dimension on the gasket being inspected (Figure 8) has a mating function, i.e., it will make a satisfactory assembly when it is at either limit of its tolerance and the mating part is at either of its limits. It, of course, will also make a satisfactory assembly when it is slightly out of tolerance when the particular part with which it mates happens to be within tolerance an amount at least equal to as much as the gasket is out of tolerance. As explained above, in Section IV-H, a 4% AOQL plan is employed. This plan holds the long run probability of defective assemblies to .0016 or less when the mating part distribution extends (beyond the particular tolerance limit that would result in an adverse assembly condition) an amount to give an area of defectives of 4% or less; and to .0016 or more when several strays are involved or when the mating part distribution is so positioned with respect to its tolerance to give a more severe condition of the type just described. Protection against the first of these adverse situations comes, qualitatively, from the representative nature of the picture of the entire lot distribution obtained from the 50 random measurements, a situation that must always be qualified by the considerations of Section V on the subject of strays. For an evaluation of the second of the adverse conditions, one should refer to the Lot Plots on file for the mating part distributions.

If the dimension has no mating function, corresponding protection can come only from taking an additional sample to get 0.1% AOQL protection on an attribute basis.

The turnover period of material in our storeroom is three months, and for any attribute sampling we have set an arbitrary requirement that it is desirable to have three separate samplings per month to give reasonable assurance of achieving the indicated AOQL protection. If the receiving records for the part number from a particular vendor indicate that two or more lots had been received within the past 30 days, for the example of a structural specification, this lot of 1000 pieces would be sampled at n = 270, c = 0, (from the Dodge-Romig SA-0.1 table). A quantity of 50 had already been sampled (Figure 8) with no pieces found beyond specification. Therefore, an additional sample of 220 pieces, checked only on an attribute basis, needs to be taken; the results are entered in the box at the lower right-hand corner of the Lot Plot form.

When only one lot of that one vendor's particular part has been inspected (Lot Plot for attributes) within the past 30 days, then this lot of 1000 would be split into two lots of 500, each being sampled at n = 210, c = 0 (actually one lot needs only a sample of 160, with the remaining lot checked at 210). If the present lot is the only one received during the past 30 days, it is split in three. On the other hand, when the present lot is the only one checked in the past 60 days, the SL-0.5 table (having AOQL's usually less than 0.1%) is employed.

When you are dealing with a mating dimension, and resort to n = 50, c = 3, the above discussion for splitting lots will apply in principle. Here, however, you are requiring 4% AOQL protection, so you employ Dodge-Romig table SA-4.0 for each of the sub-lots into which you split the received lot (less the one lot already checked at n = 50, c = 3). For the 60-day situation, SL-4.0 is arbitrarily selected.

C. Figure 9 represents a condition often encountered: a normal population extending beyond one specification limit—Type 3. In handling this situation, the object is to determine an estimate of the percent defective of the lot, and of the extent of the error of the worst piece "likely" to be existing in the lot. When this information is entered at the bottom center of the form, it then also serves as a "Salvage Order," the disposition of the lot being entered in the left-hand bottom box.

In the event the lot is not acceptable, a notation as to the disposition—either "Return to Vendor," or "Screen at maximum (or minimum) value of . . . . . until . . . . . pieces are found acceptable. Return remainder to vendor"—is entered in the "Remarks" space.

In this example, the extent of the error is .0028 beyond high limit, since the upper lot limit is 2.8 cells beyond the HL (high or upper specification limit) and each cell is .001. The 4% figure for the percent of the lot beyond

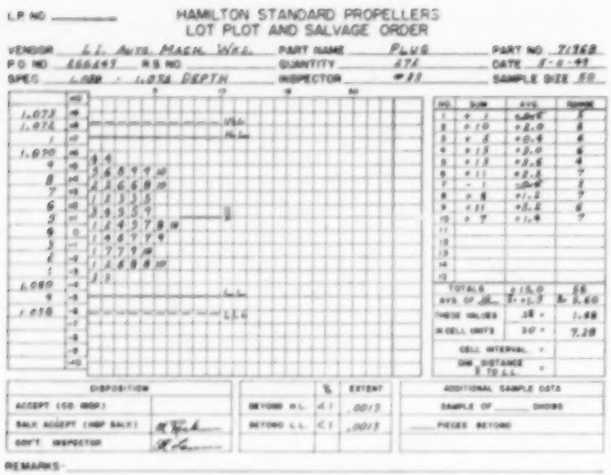


Figure 10—**Lot Plot for Plate I—Type 4**

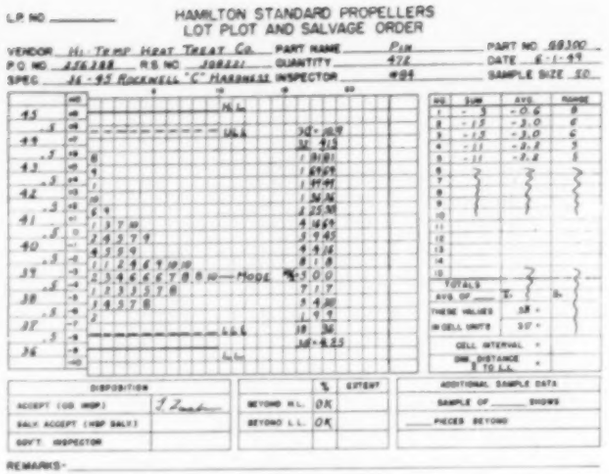


Figure 11—**Lot Plot for Plate I—Type 5**

this limit comes from entering distances D and W, 2.8 and 13.6 cells, respectively, in Chart A. Since the lower lot limit is inside the low drawing limit (LL), no pieces are expected beyond that point, and "OK" is entered in the appropriate box.

While Chart A has been computed from the areas under a normal curve, it is not necessary that the sample of 50 give a frequency histogram that has perfect normal curve proportions. It should be realized that sampling errors can lead to reasonable variations in individual cell heights, but that the estimates of average and standard deviation from the sample of 50 can be used with the high degree of assurance typically illustrated in Figure 19 and computed to give the operating characteristic curve of Figure 21, when the distribution of the sample is normal or nearly so.

D. When the distribution of the Lot Plot sample has a flattened top, and is reasonably symmetrical, Figure 10, the lot limits as computed from the average range will always be further out than the points which will include 99.7% of the sizes in the lot. Therefore, the use of these limits for a Type 4 situation in the same manner as described just above in Section C, will in all cases be somewhat more conservative than is defined by the operating characteristic curve of the plan.

E. Usually characteristic of physical properties of material, such as hardness and tensile strength, and sometimes found with other quality measures, is a lopsided or skewed distribution, Figure 11, characterized by a long tail on one side and a much shorter one on the other. For this Type 5 case, entries of sum, average, and range need not be made as soon as the uneven nature of the developing distribution is recognized. The lot limits, instead, are estimated from considering the distribution as being made up of two normal curves, each split at its mode. Charts C_1 and C_2 are computed on the basis of a mirror image of one side of the distribution existing on the other side of the mode. Accordingly, ΣF and ΣFX^2 totals are needed for each side to enter the appropriate chart.

The tabulation to the right of Figure 11 differs from that of Figure 3 only in arrangement. The center column records the square of the cell distances from the mode. Zero, 1, 2, 3, etc., becomes 0, 1, 4, 9, etc. The first column contains the number of pieces found in each cell (½ the number for the mode cell) and the right-hand column lists the product of the multiplication of the first two column entries for each cell. In adding the first and

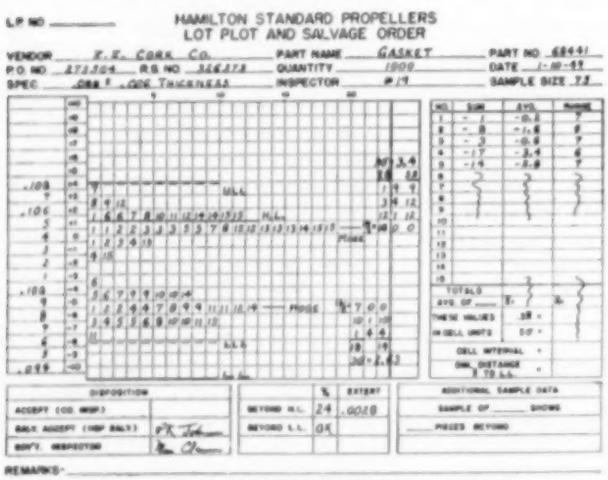


Figure 12—**Lot Plot for Plate I—Type 7**

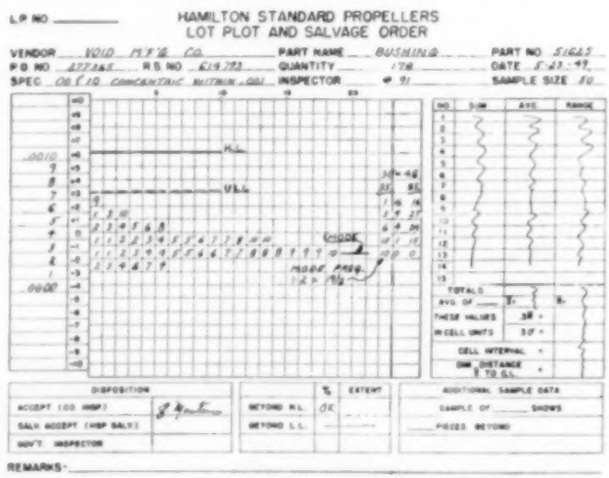


Figure 13—**Lot Plot for Plate I—Type 8**

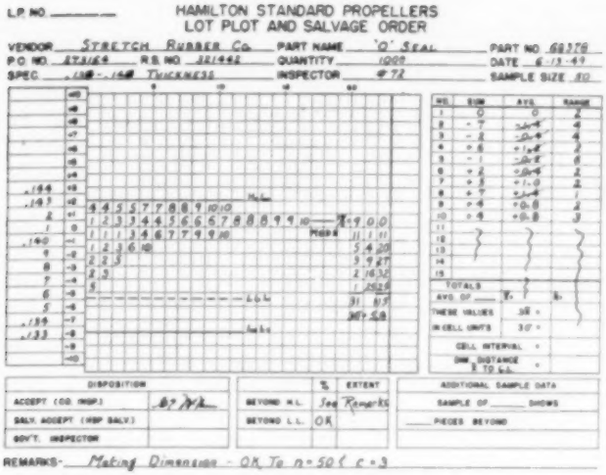


Figure 14—**Lot Plot for Plate I—Type 9**

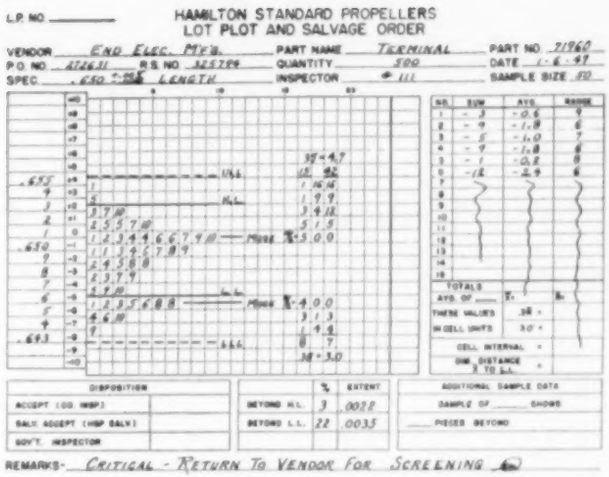


Figure 15—**Lot Plot for Plate I—Type 10**

third columns, for ΣF and ΣFX^2 respectively, one must start at the mode position and add up for the totals of 32 and 413, and down for 18 and 36. The first pair of figures entered in Chart C_1 give 10.9 cells from the center of the mode cell to the upper lot limit, and the latter two numbers in Chart C_2 result in 4.25 cells for the position of the lower lot limit.

F. Figure 3 is an example of a distribution that is apparently a normal one, but with one tail cut off. The end with the tail is treated as above in Section E for the skewed distributions.

The cut-off end should be handled in the most appropriate one of three ways, depending upon the conditions. With reference to the discussion of Section IV-F, one may want to use the right-hand side of Chart A—Extended, particularly if it is *known* that a process limitation exists at the .1240 value. On the other hand, the 4% AOQL supplementary attribute plan or the 0.1% AOQL may be more appropriate, depending upon whether the dimension in question is a mating one (as in Figure 3) or a structural one. If it were the latter, an additional sample (in accordance with the discussion above in Section B) would be taken and the results entered in the lower right-hand box on the form.

G. The two distributions of Figure 12, Type 7, called for an additional 25 pieces to make a total sample of 75, to give sufficient data outward from each mode to be able to use the method of half a normal curve which involves the use of Charts C_1 or C_2. In such a case, however, no notation need be made in the right-hand lower box. Here again, sum and range entries are discontinued as soon as the non-normal nature of the distribution becomes apparent. The 24% of the lot beyond high limit comes from 2.8 cells from HL to ULL, 6.6 cells from twice the 3.3 cells from the MODE to ULL, 52 from twice the ΣF of 26, and 75 the sample size. The 2.8 and 6.6 give 34% from Chart A or A—Extended; and 52/75 of 34% is 24%.

H. A typical Type 8 half-normal distribution is illustrated by Figure 13. The inspector, checking concentricity, expected to get this final picture. He, accordingly, did not make any sum and range entries. Computation of the one lot limit by the mode method shows the characteristic to be within specification, allowing acceptance.

I. Figure 14 (Type 9) is simply a wider Figure 3 distribution where the full or "effective" width is greater than the tolerance. Here the cut-off comes on the specification limit. The n = 50, c = 3 attribute plan is satisfied for this mating type dimension, and ac-

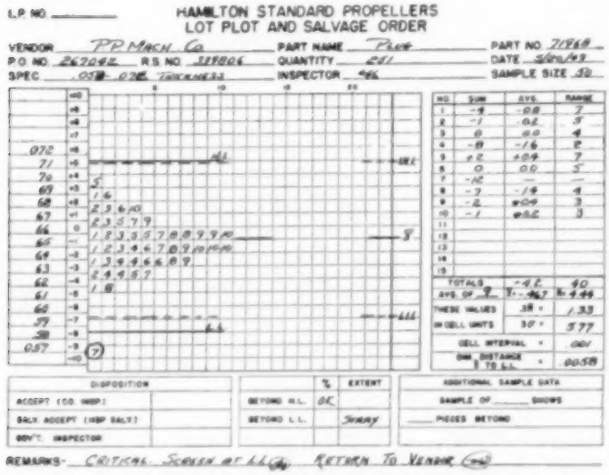


Figure 16—**Lot Plot for Plate I—Type 11**

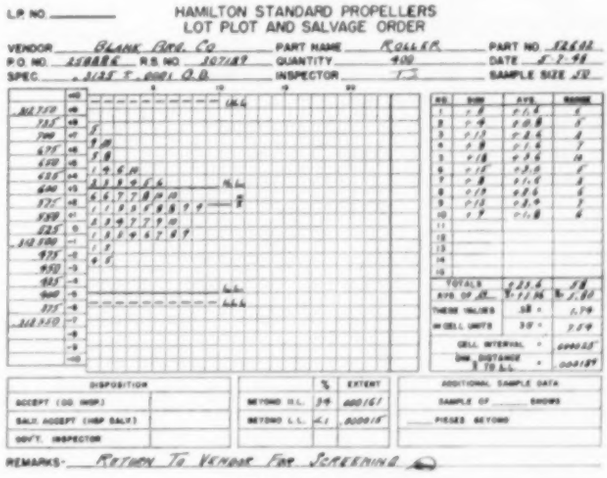


Figure 17a

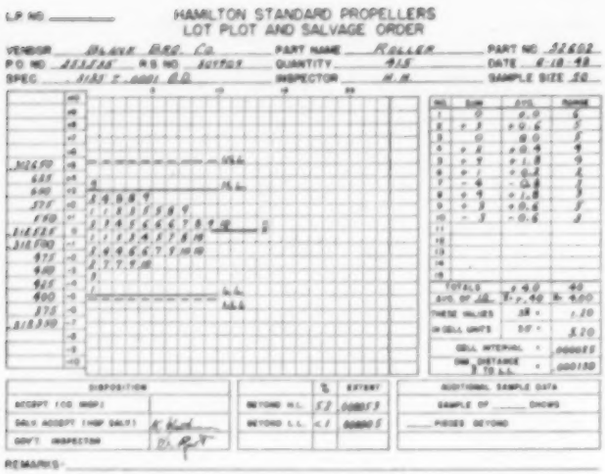


Figure 17b

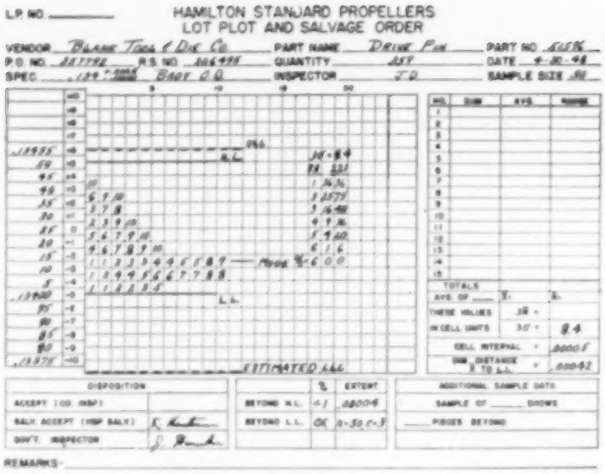


Figure 18a

ceptance follows.

J. The two normal distributions in Figure 15 overlap with tails extending beyond specifications. Sum and range entries are again disregarded. The percentages and extent of errors of this Type 10 distribution are computed from Chart A after finding lot limits by the mode method. Note that Chart A cannot be used directly to find the percentages. These Chart A percentages must be multiplied by the ratio of the quantity in each distribution to the total of the two. Estimate the ratio by doubling the total frequency used to compute the lot limit and dividing it by the sample size. In Figure 15, the upper distribution ratio is (15 x 2) ÷ 50 = .60 and the lower ratio is (8 x 2) ÷ 50 = .32. The 2.2 cell extent beyond HL and the 2 x (3σ = 4.7) = 9.4 base width of the upper distribution give a 5% value from Chart A. 5% multiplied by the .60 ratio results in a 3% final estimation for pieces above upper specification. Similarly, for the lower distribution, the 3.5 cell extent beyond LL and 2 x (3σ = 3.0) = 6.0 base width give a 69% Chart A value. This 69% multiplied by the .32 ratio yields a 22% figure. Salvage consideration of errors indicates that over HL parts would make good assemblies but short length pieces could give poor contact characteristics even when statistical combinations are computed. At this limit, screening is the answer.

K. It is not unusual to have an acceptable Lot Plot with the exception of a stray or two. This Type 11 problem is illustrated by Figure 16. Since low thickness could cause detrimental leakage, screening is necessary. If this had not been the case, the size of the worst expected stray could have been determined and considered for salvage acceptance. For example, one stray piece has been found in this sample from the lot of 251. The 1 entered on the horizontal scale and the 251 entered on the lot size curves of Chart D give an expected stray quantity of 10 on the vertical scale. This 10 entered on the angular lines and the ΣR of 40 entered on the vertical scale of Chart E give a 7⅛ value in the bottom horizontal scale, indicating that the worst expected stray is 7⅛ cells lower than the detected one. Its size is .0565, less .0071, or .0494. If salvage review had showed that one plug thickness of .0494 could be allowed in the lot, the lot could have been accepted through salvage with no further inspection.

Occasions may arise with strays showing on a bimodal or skewed distribution where lot limits were computed by the mode method. If an additional sample had to be taken, then the expected number of strays found from Chart D (as if the sample were 50) has to be reduced by multiplying by the ratio 50/(total sample size). An equivalent ΣR value is needed for Chart E and can be found by multiplying the 3σ value in cells (distance from mode to lot limit) by 7.7 since (ΣR) (1.29)/10 = 3σ, whence ΣR = (7.7) (3σ).

L. The ability of Lot Plots to point out correctable process characteristics is illustrated in Figures 17 and 18. The process spread for the bearing O.D.'s in Figure 17a is 90% greater than the tolerance. The vendor, upon receipt of his copy of the Lot Plot, instituted a program to eliminate grinding variation which resulted in the Figure 17b picture. Although specifications are still violated, the quantities and errors are much smaller.

Figure 17a serves well to assist in developing one's judgment as to the method of analysis to use. If the mode method had been employed using the cell bounded by +1 and +2 as the mode, ULL would move down 0.2 of a cell and LLL would move up 1.2 cells. Then, keep in mind that each cell represents 25 millionths of an inch, and that repeated samples of 50 will change somewhat in shape within limits dictated by the sample size.

The pin grinding process of Figure 18a had a natural spread greater than the tolerance. The vendor screened out the small pieces at considerable cost. Figure 18b shows the results of his first attempts to reduce machine spread. It indicated that for a small portion of the run the operator had moved the setting in the desired direction, but had overcorrected. The new spread was acceptable but either some of the former run material was present, or the indicator gage had been bumped, changing its setting .0003" without the operator's knowledge. The copy of the second Lot Plot was valuable to the producer in clearly showing this, as is apparent from the results of Figure 18c. Decrease of the

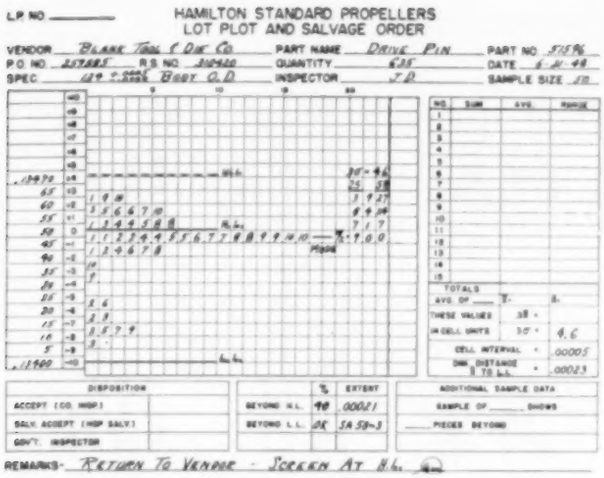

HAMILTON STANDARD PROPELLERS
LOT PLOT AND SALVAGE ORDER

Figure 18b

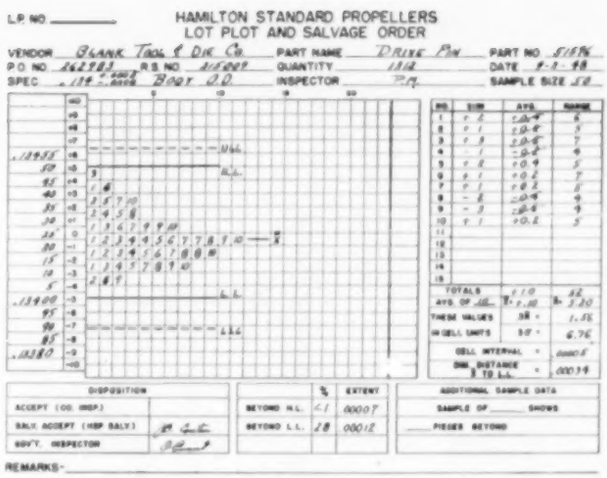

HAMILTON STANDARD PROPELLERS
LOT PLOT AND SALVAGE ORDER

Figure 18c

natural spread from .00084 to .00068 and recentering toward the basic specification size produced approximately 4% defectives with correspondingly small errors which could be allowed through Salvage consideration. The cost and questionable risk of screening was eliminated.

M. For those industries not having such critical safety requirements attached to their product, an almost obvious recommendation lurks among these statements about the Lot Plot plan. The permissible use of AOQL's that are not tight economically invites the use of attribute sampling. When a sample is found to contain more than the allowable defects, the rules call for 100% screening. Usually the lot size is fairly large, so why not prepare a Lot Plot at this stage? The resulting estimate of percent defective can then be compared with the allowable AOQL and the extent of the error is determined, both of which factors help to decide whether the screening will even be necessary. In our experience a small standard deviation with an improper average position is not uncommon.

In many cases the need for screening will be confirmed by the Lot Plot, but now the bugaboo of inspector fatigue which can affect the 100% inspection has had a restraining check upon it. The approximate number of defective pieces to be found and to be removed from the lot is known! The Lot Plot, moreover, will give the vendor the necessary information on which to base his corrective action.

IX. THE BACKGROUND

The background upon which the Lot Plot plan was developed may well be introduced by an analysis of the accuracy of conventional 100% inspection practices and results. Statements such as "absolute certainty as to the quality of a given lot of product can result only from 100% inspection," "anything less than total inspection will yield less-than-certain information regarding the quality of product," represent a theoretical axiom on which many statistical quality control sampling plans depend. The 100% inspection requirement of all rejected lots to be able to keep overall quality within the AOQL figure is an example of this type of thinking. To be practical we have to admit that "total inspection" is not 100% inspection, but rather is approached by conducting the 100% checking several times. It is perhaps close enough only after 300% or sometimes as much as 3,000% inspection, depending upon many conditions. The condition normally having the greatest effect is one of inspector fatigue, and this, almost paradoxically, is a function of the total number of parts inspected.

The Lot Plot plan provides better results than those obtained by 100% inspection by reducing the number of parts inspected from each lot, and so reduces the inspector fatigue item. It also provides gaging accuracy commensurate with the natural tolerance of the part. In other words, it divides the plus and minus three standard deviation spread into a minimum of seven divisions and requires that the gage be able to pick out these increments. The reduced expenditure of inspection time, moreover, makes a line type of inspection practical, where each dimension on each part or pair of parts is checked in sequence. This variety of attention coupled with only 50 pieces inspected virtually eliminates the fatigue or "boredom" factor. A random cross-section of this plan in action took place when, with the confirming attention of the Government inspectors, we made a cross-check in each case of the results found by the conventional 100% inspection as well as those found by Lot Plot analyses for 61 lots ranging from 70 to 2700 pieces in size. In three lots the 100% inspection found errors not discovered by the statistical method, but the fraction defective in each case was very much less than the 0.3% risk figure which we accept as being characteristic of three standard deviation limits. In fact, totalling the three lots in question, only 4 defective pieces were found, which represents an error of 0.063%, or about 1/5 of the total acceptable risk. A total of 701 pieces were rejected by 100% inspection, and thus 697 represents the number of pieces found also by the Lot Plot plan. In addition, in the samples themselves, 565 pieces were found in error. These figures alone would indicate that the statistical method finds 80% more defectives than does the 100% method. It should be remembered, though, that in addition to finding errors in the sample itself the Lot Plot in several cases indicated the presence of errors in the lot which didn't appear in the sample. It is, therefore, correct to say that the Lot Plot method represents considerably more than 80% improvement

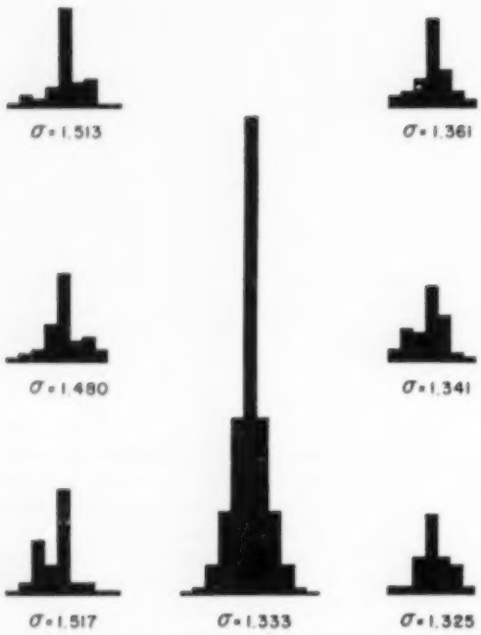


Figure 19—**Histograms for Random Drawings of Chips from the Parent Universe Shown by the Center Histogram**

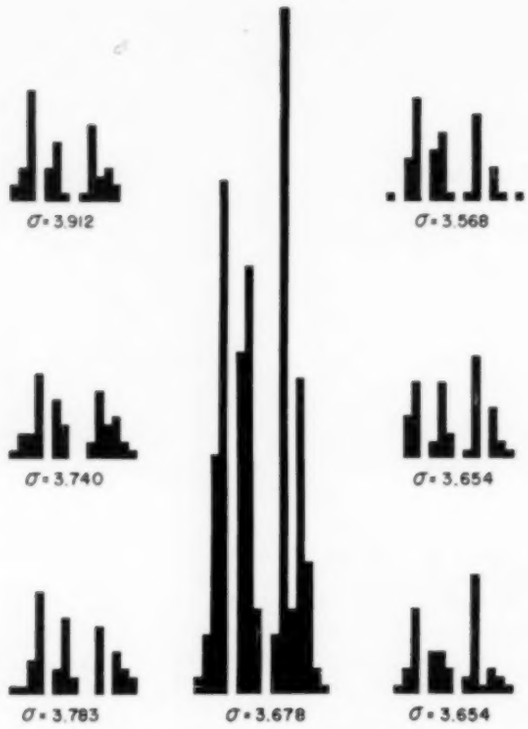


Figure 20—**Histograms for Random Drawings of Chips from the Parent Universe Shown by the Center Histogram**

over the 100% checking in its ability to indicate the presence of individual defective pieces.

To assist in confirming the judgment of selecting a sample size of 50, many random drawings of chips were taken from two bowls. In one bowl the chips were marked in accordance with a normal distribution and in the other the distribution was definitely non-normal. Typical drawings are shown in Figures 19 and 20.

It will be seen that reasonable agreement with the parent universe in the center was obtained with respect to the average value, standard deviation, and the general outline. In the case of the drawings from the normal universe, a few instances of noticeable bunching of frequencies near the middle with long tapering legs (leptokurtic distribution) were found in the sample. Since the condition was easily recognizable, the samples could be classified and handled as one of the eleven types pictured in Section III, and thus handled adequately.

An evaluation of the overall accuracy of the Lot Plot method first involves a recognition that the taking of finite samples introduces errors in estimation of $\overline{X}'$ and σ'. Such errors are exhibited in a Lot Plot that shows skewness or kurtosis (flattened or peaked distributions) in a direction away from normal when the parent universe is normal, or skewness or kurtosis to a different degree than that of the parent universe. In either case the use of the special methods for analysis of borderline cases previously illustrated tends to check the effect of the error in $\overline{X}'$ and σ'.

The most severe errors in determining the absence or presence of defectives occur when the parent distribution is close to or is normal, and no special methods are employed when the lot limit is in the vicinity of the specification limit. Here, since the lot limit position is affected by both the chance values of the sample's $\overline{X}$ and σ, but three times as much by the latter, the statistical combination of the standard deviations of each statistic to obtain the standard deviation of the lot limit is shown on the right-hand side of Figure 2. The operating characteristic curve of Figure 21 was developed from this relation, by assuming given values of percent defective of the universe and getting the proportion of the lot limit distribution that will fall within specification, as the probability of acceptance.

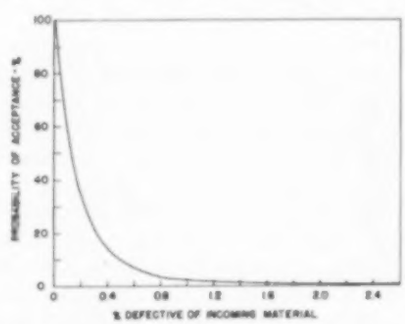


Figure 21—**OC Curve for the Relation Shown in Right Half of Figure 2**

The equivalent curve for an attribute sampling plan would involve a sample size of about 500 pieces, or 10 times that required by this variable Lot Plot plan. One of the criticisms of this curve might be the low producer's risk: 5% of the time a lot which is as good as 0.01% defective can be rejected. All "rejected" material, however, as mentioned before, is subject to special disposition by considering its probable effect as assembled. In practice, this modification, which is made feasible by the variable picture of the Lot Plot, nicely takes care of the producer's risk situation. It tends to give us the effect of a square-shouldered operating characteristic curve, the unattainable goal of every inspection plan.

REPORT OF THE

Fourth National Convention, ASQC, and the Fifth Midwest Quality Control Conference

Milwaukee, Wisconsin, June 1-2, 1950

Although final statistics are not available as this issue goes to press, it appears that about 1400 persons officially registered their presence at the Milwaukee Auditorium for the two-day meetings and activities of the Fourth Annual ASQC Convention and Fifth Midwest Conference June 1-2. At least 34 states and 338 companies are represented in this registration, so that the program can truly be said to have drawn national recognition among personnel interested in statistical quality control. Canada and Spain were also represented among the registrants.

A brief resumé of features of these meetings would include the following:

1. The Open House at the Pabst Blue Ribbon Hall on the evening of May 31st at which the Pabst Brewing Company was host to the vanguard of the convention. Here was food and drink and good fellowship in abundance. Pabst's hospitality on this occasion will be warmly remembered by all who had the opportunity to enjoy it. The fact that Pabst has an active interest in SQC will also be remembered by those who took advantage of the several inspection tours of the plant conducted during the evening.
2. A well-balanced and well attended series of ten clinic sessions. Speakers on this part of the program came from as far apart as New England and California to bring to the respective audiences a wide range of both technical and applied topics representing the latest thinking and practices in the field of statistical quality control.
3. The Educational Sessions which have always been an integral part of Midwest Conferences again drew a heavy attendance to hear the philosophy, concepts, and basic techniques of SQC explained by members of a five-man staff nationally known as teachers in this field. The final session of this series was still playing to a full house as late as 4:30 on Friday afternoon.
4. An exceptionally fine display of gage and equipment exhibits that received the well deserved attention of a steady flow of people interested in the latest developments in this field which is such a vitally important complement to the proper application of SQC techniques.
5. The very fine and unusual special exhibits furnished by the Army Ordnance and Naval Ordnance respectively. The impetus and continuing support that these two branches of the armed services have given to the statistical quality control movement in this country are well known, so that the presence of these exhibits was especially stimulating and appropriate.

Part of Naval Ordnance Exhibit

Part of Army Ordnance Exhibit. Shown also are George D. Edwards, Past President of ASQC, and General Leslie E. Simon, 1948 Shewhart Medalist

Walter Shewhart, E. L. Grant, and Ed Olds discuss a typical quality control poster in the Exhibits Hall

Harold Dodge, 1949 Shewhart Medalist, and Len Seder, winner of the first Brumbaugh Award, listen to a tall one by Ralph Wareham (center)

6. The impressive array of SQC posters that lined the walls of the several exhibit halls. These posters reflected graphically and pictorially the experience, progress, case histories, and results of many companies and industries in putting SQC to work in manufacturing operations of a wide and varied nature.
7. The "new deal" in Conference Papers. This year, for the first time at a national meeting of ASQC, separate, full-text copies of each of the ten clinic papers were available for sale in such quantities and selection of titles as the individual purchaser desired. Each of these papers was an unedited, full-text pre-print of the speaker's treatment of his topic, with publication rights reserved to Industrial Quality Control. Although the sale of these papers at the conference reflected an emphatic endorsement of this new policy, there were 2000 copies of each paper initially printed, so that there remains a fairly ample supply of most of the titles published. Copies are available as per the boxed notice on this page.
8. Special events for the ladies. The distaff side of SQC was well represented at this convention. The presence of such an unusually large number of ladies lent a charm and grace to the occasion that was most pleasing. For the ladies, a series of special events had been arranged including a luncheon at the famous Schwabenhof Restaurant and a sightseeing tour of Milwaukee. Come again, girls!
9. Meetings for the conduct of Society business. Beginning on Wednesday afternoon, May 31, and continuing through noon on Saturday, June 3, there was an almost steady progression of Committee and Board meetings of ASQC. With such wide geographic representation at this convention, these meetings were uniformly well attended by the personnel directly concerned, and many matters of importance to the conduct of Society operations were discussed and acted on.

ANNUAL ASQC BANQUET

In opening the program of the dinner meeting at the Hotel Pfister on Thursday evening, R. S. Saddoris, General Chairman of the Conference Planning Committee, neatly summarized the sentiments of many in the audience when he said, "Probably never before have so many of the outstanding personalities in statistical quality control been assembled in the same place at the same time. For example, in my own case, until now Dodge and Romig have just been names on the cover of a book, but here they—and others of similar fame—are among us in person."

Appearing as opening features of the banquet meeting were the High Life Quartet of the Miller Brewing Company, which ably entertained the audience with some well-chosen close harmony, and Mayor Zeidler of Milwaukee, who brought official greetings to ASQC and the Convention on behalf of the City of Milwaukee.

Mr. Saddoris then turned over the gavel to Ralph Wareham, President of ASQC, whose initial act was to confer on Mr. Saddoris the first of the new Fellowship pins adopted as standard at the May 31st meeting of the Executive Committee, and to express that Committee's vote of appreciation for the services rendered the Society by Mr. Saddoris as General Chairman of the Planning Committee.

President's Report

In his Report on Society Affairs, Mr. Wareham spoke, in part, as follows:

"This is the 26th anniversary of quality control. It was just 26 years ago that Dr. Walter A. Shewhart conceived the idea of an industrial control chart and placed his recommendations before officials of the Bell Telephone System. Last Octo-

NOTICE

Copies of each of the ten clinic papers prepared in conjunction with the Fifth Midwest Conference program are available either singly at 30c per paper, postpaid, or in sets of ten at $2.50 per set, postpaid. Send order and remittance either to Alfred L. Davis, Rochester Institute of Technology, Rochester 8, N. Y., or to P. O. Box 1204, Milwaukee, Wis.

Inquiries have been received regarding the Training Manual used at the Educational Sessions. These are available as specified on p. 89 of the May, 1950, issue of IQC.

Ralph Wareham presents the first of the newly adopted Fellow Grade lapel pins to Ray Saddoris

Newly-elected officers of ASQC. Left to right: Simon Collier, Martin Brumbaugh, Wade Weaver, Alfred Davis

ber, the Bell Telephone Laboratories presented the Society with a plaque reproducing the original letter from Dr. Shewhart to Mr. R. L. Jones. This was reproduced on the January cover of Industrial Quality Control, and the original plaque has been placed in the Society's national office.

"In the 26 years since the original quality control proposal, much water has gone over the dam. The first ten years constituted a period of testing the applicability of the methods within the Bell Telephone System. The following ten years, which included the first War years, were the years in which the methods were tested and increasingly applied by other companies in diverse industrial fields. The last six years have witnessed management acceptance of the principles of modern quality control, and management organization for full use of the methods in industrial operations. The war-time order of General Somervell that 'Statistical quality control will be used so far as possible throughout the Army Service Forces' and the recent statement in Fortune magazine that 'Statistical quality control is among the sharpest management tools developed in half a century . . . In most industrial circumstances, statistical quality control represents by far the most economical way of controlling the quality of a product or process' — are indications of this management approach to the problem.

"The American Society for Quality Control has grown rapidly and steadily since its organization in February, 1946, as a part of this tide toward modern quality control methods. The American Society—under its constitution—is actually a federation of individual quality control groups in 42 cities. Only such powers as must be centralized for the common good are vested in the national organization; all other matters are handled by our Sections or groups of Sections. This somewhat complicates the job of coordinating the activities and program of the Society, but it has the decided advantage of giving us strength through the teamwork of many hands. We are a young society and such teamwork is absolutely necessary.

"It is a pleasure to report to you on the affairs of the Society at the close of my two years of stewardship as President of our Society. As to membership, we have had an increase from 2092 two years ago to 3475 today. There has thus been an increase of 1383 members during the past two years, or a growth of 66%.

"Two years ago we had 31 Sections of the Society; today there are 42. The new Sections are Cincinnati, South Texas, Muncie, New Hampshire, Toledo, Columbus, Denver, Erie, Greater Muskegon, San Francisco Bay Area, and Rhode Island.

"This growth in membership and Sections has materially strengthened the work of the Society throughout the country.

"But — aside from numbers — our Society has steadily grown in program, activities, and relationships between members. Our Sections have made definite efforts during the year to determine the types of programs of greatest value to Society members; they have arranged these types of programs. Many Sections have also provided educational courses and lectures on statistical quality control methods as a service to our members; these courses have supplemented formal program presentations. The high attendance at Sectional and Regional meetings attests to how well these efforts have succeeded.

"It has been a privilege to serve as your President during the past two years. The Officers of the Society have worked together as a team to carry through the Society's responsibilities. Wade Weaver, as Vice President, has handled many key jobs that needed to be done and has given excellent leadership to matters relating to publications organization, national office organization, and procedures for operation of the Regions. Si Collier and I have been in constant contact in decisions regarding Society memberships and activities. Al Davis has handled with skill and efficiency the financial affairs of the Society, and Mason Wescott has excellently carried the responsibilities for publications of the Society. They have formed a resourceful team for the Society. To each of them, I hereby express the thanks of the Society and my personal appreciation.

"The increasing activity of our committees has stimulated the work of the Society. Special mention should be made of the three new technical committees which have been formed during the past year. The first was the Chemical Technical Committee of which Mr. Roland H. Noel is Chairman; the second was the Electronics Technical Committee of which Mr. Leon Bass is Chairman; and the third is the Automotive Technical Committee of which Mr. Richard D. Long is Chairman. These committees will serve as clearinghouses for quality control information in their respective fields and will provide information on quality control applications in these fields. It is contemplated that similar technical committees will be established in other industrial fields in the future. The formal organization of each committee will consist of a Chairman, a Vice Chairman, and a Secretary, leaving the way clear for

individual members to work with the committees at any time.

"The Executive Committee of the Society met in October in New York, in December at Princeton, New Jersey, in February in New York, and yesterday here in Milwaukee. The decisions reached at these meetings have been and will be reported in the succeeding issues of Industrial Quality Control.

"During the past two years, your President has addressed the meetings of many Sections of the Society. It was a pleasure and privilege to take part in these programs and to meet the individual members of the Sections.

"In addition, the other national Officers have visited many more Sections, so that the American Society has been represented as widely as possible at Section meetings and Regional conferences."

Brumbaugh Award

Following his report, Mr. Wareham introduced Halsey H. Kent, Chairman of the Brumbaugh Award Committee, who spoke in part as follows:

"In reviewing our national organization it is to be remembered that we started the hard way with a number of willing workers, with little or no cash assets; however we did fall heir to one very strong asset, the magazine called 'Industrial Quality Control' first published in July 1944 by the Buffalo Society of Quality Control Engineers in cooperation with the University of Buffalo.

"In February of 1948, it was the pleasure of the Rochester Section to combine the Second Annual Convention of the American Society for Quality Control with the Fourth Annual Rochester Clinic. At this convention a substantial profit was shown and it was the wish of the Rochester Section that this profit be earmarked for the benefit of the American Society for Quality Control and the science in general. Accordingly $1000, or one half the profit, was given outright to the Society. What to do with the other half was the subject of considerable discussion as to how it could be made to best serve the interests of this new society and science.

"After reviewing broadly the history of the Society plus many other instances of personal sacrifice contributing to its growth, the Rochester Section recommended to the American Society for Quality Control that it consider using the money for setting up a Brumbaugh Award. In this way well written articles would be encouraged for publication in our journal, for the common good of all, and capable writers encouraged to relate their accomplishments and ideas. This award would also be in recognition of the early monumental work done for the Society by Martin Brumbaugh, founder and first editor of the magazine Industrial Quality Control.

"The above suggestion, having met with favorable action of the Executive Committee, was approved on June 17, 1948.

"Tonight, your President is to make the first award to the author of the paper published in Industrial Quality Control that has been judged by your committee, through your nominations, to have made the greatest contribution to the development of industrial applications of quality control."

Mr. Wareham then introduced the Award winner, Mr. Leonard A. Seder, and presented him the First Brumbaugh Award with the citation:

"The Society has selected you for the first Brumbaugh Award, in recognition of your outstanding paper on 'The Technique of Experimenting in the Factory,' as published in the March, 1948 issue of Industrial Quality Control."

In response, Mr. Seder fittingly remarked:

"Thank you very sincerely for this great honor. I accept it humbly and gratefully.

"However, I feel that I am an imposter. The ideas expressed in the paper were not mine, but were the product of much more capable minds and pens. They belong to those pioneers in industrial experimentation who long ago bravely offered predetermined risk in place of haphazard guesswork. These ideas were interpreted and modified by many great teachers, some few of whom I have been privileged to know and to borrow from. If there is merit in the manner of my presentation of these ideas, then it is because of the penetrating questions and critical review of my own teachers and students.

"I therefore accept this award on behalf of my teachers and on behalf of those many other experimenters of tomorrow. Especially do I accept on behalf of the greatest teacher of statistical experimentation—Dr. R. A. Fisher."

Shewhart Medal

In conferring this year's Shewhart Medal Award, Mr. Wareham first introduced Mr. Philip L. Alger, Chairman of the Shewhart Medal Committee, who reviewed the story of this award with the comments:

"The directors of our Society established this Medal Award in 1947, to do honor to our distinguished fellow member, Dr. Walter A. Shewhart, and to inspire others to emulate his pioneering spirit, technical achievements, and generosity of spirit that have so aroused our admiration.

"The award is made for outstanding leadership in the field of modern quality control, a prescripition that gives the Medal Committee wide latitude in selecting the individual to be honored. As you may well imagine, many thousands of words have been exchanged in letters and arguments before we could agree; but in the end, I am glad to say, our choices have been unanimous.

"The first award of the medal was fittingly made to Dr. Shewhart himself, for the year 1947, and the second was made last year to our distinguished fellow member, then Colonel, now General, Leslie E. Simon. This year we have selected another of the several pioneers who have contributed greatly to the young science of statistical quality control, whose record will be presented to you by Professor Edwin G. Olds."

The citation for the 1949 Medallist, as presented by Professor Olds, is given herewith.

"The Shewhart Medal Committee has accorded me the privilege of presenting Mr. Harold French Dodge for the award of the 1949 Shewhart Medal. It is an honor for which I am deeply grateful.

"Harold Dodge was born in Lowell, Massachusetts. He received the Bachelor of Science degree from Massachusetts Institute of Technology in 1916 and the Master of Arts degree from Columbia University in 1922. Following his graduation from Massachusetts Institute of Technology, he served his alma mater for a year as an instructor of electrical engineering. In 1917 he became associated with the Western Electric Company as a develop-

ment engineer, serving in that capacity until 1925 when he took the post which he still holds as Member of the Technical Staff and Quality Results Engineer at the Bell Telephone Laboratories.

"In 1918 a young physicist, named W. A. Shewhart, joined the Western Electric Company and, in 1924, he became a member of the Technical Staff at Bell Telephone Laboratories. So in 1925 we find Walter Shewhart and Harold Dodge at adjoining desks, working together on the application of statistical principles in the improvement of the quality of manufactured products.

"Then was the time that Harold Dodge began to make those contributions which justify the current issue of Industrial Quality Control in describing him as 'an individual noted for outstanding leadership in the field of modern quality control.':

"1928—'A Method of Rating Manufactured Product';

"1929—(with Harry Romig) 'A Method of Sampling Inspection';

"1935—A lion's share of the work in preparing the 'A.S.T.M. Manual on Presentation of Data.' Supplements A and B were largely based on a training course he gave for Bell Laboratories' engineers;

"1941—(with Harry Romig) 'Single Sampling and Double Sampling Inspection Tables' (published later as a book);

"1941-1942 — Chairman of the Committee which prepared the famous 'Z' standards for the American Standard Association, $Z_{1.1}$, $Z_{1.2}$, $Z_{1.3}$. The last, 'Control Chart Method of Controlling Quality During Production,' has had more than 33,000 copies issued. For many of us it was our first introduction to the field of statistical quality control.

"1942, 1943, 1944—Consultant to Secretary of War on Quality Control and Sampling Procedures; one of a small group responsible for the Army Ordnance Tables; instructor in Army Service Forces Training Conferences.

"1943 — 'A Sampling Inspection Plan for Continuous Production.'

"These are notable tasks ably completed. But his work in our behalf does not cease. To mention just a few of his current assignments, he is on the Editorial Board of Industrial Quality Control, Chairman of the Standards Committee of ASQC, and Chairman of the Technical Committee E-11, on Quality Control of Materials, of the American Society for Testing Materials.

"I deplore the lack of time to give any adequate description of Harold Dodge's contributions to the sane development of statistical quality control in industry. I would like to have taken his writings, one by one, and to have pointed out the original and inspired ideas they encompass. Then I would like to have gone beyond his publications and revealed to you, Harold Dodge, the man, as I have had the good fortune to know him. I would like to have dwelt on his fearlessness, his intellectual honesty, his unselfishness, his generosity, his devotion to his family and loyalty to his friends, and all of those other sterling qualities which he shares with the man in whose honor the medal is being given and with the man to whom it was awarded last year. I wish all of you could know him well because then you could not help agreeing with me that, by accepting this medal, it is Harold Dodge that bestows the honor and our Society upon which it is bestowed.

"Mr. President, on behalf of the Shewhart Medal Committee, I present to you and to this assemblage, the unanimous choice as the Shewhart Medalist for 1949, Mr. Harold French Dodge."

The Shewhart Medal, established by ASQC "for outstanding leadership in the field of modern quality control" was thereupon awarded for the year 1949 by Ralph Wareham as President of ASQC to Mr. Harold F. Dodge "in recognition of his many original contributions to the art of statistical quality control, his pioneer achievements in scientific sampling inspection, and his leadership in the development of quality control standards for industry. These contributions have exerted a deep and stimulating influence on the founding and growth of quality control as a new engineering profession."

Mr. Dodge's acceptance address on "Inspection for Quality Assurance" is published in full elsewhere in this issue.

Teller's Report and Adjournment

Following Mr. Dodge's address, President Wareham reconvened the Annual Meeting of the Society to receive the official report of the Tellers Committee on the election of officers for the forthcoming fiscal year. Mr. Harry C. Romig, Chairman of the Tellers Committee, gave the report, on the basis of which Mr. Wareham declared the election of Wade R. Weaver, as President, Martin A. Brumbaugh as Vice President, Simon Collier as Executive Secretary, and Alfred L. Davis as Treasurer of ASQC for 1950-51, and, calling on Mr. Weaver, said "It is with complete confidence and much personal satisfaction that I turn to you the gavel and affairs of the American Society for Quality Control."

President-elect Weaver, in acknowledging his induction, took occasion to make, as his first official act, the presentation to Ralph Wareham of a memorial gift of several fine pieces of personal luggage. This gift came as a joint contribution from the many members and close associates of Ralph Wareham who thus wished to express their esteem and affection for his four years of tireless, loyal service as an officer of the Society.

The meeting was thereupon declared adjourned.

FRIDAY LUNCHEON SESSION

Approximately 1300 persons attended the Friday luncheon in Bruce Hall at the Milwaukee Auditorium.

The Romany Singers, an all-girl chorus, opened the program for this session with a number of appropriate songs delightfully sung.

Mr. Paul A. Pratt, for the Milwaukee Association of Commerce, and Mr. William S. Wood for the Wisconsin Manufacturer's Association brought greetings to the convention from these organizations, each of which has had a major part in helping to promote the success of this year's joint Convention and Conference.

The featured speaker at this luncheon session was Mr. Lewis D. Crusoe, Vice President of The Ford Motor Company and General Manager of the Ford Division. Mr. Crusoe spoke on "What Management Expects from Quality Control," emphasizing in particular the dependence of product quality on the human element of pride in workmanship. His paper is published in full elsewhere in this issue.

Mr. Wade Weaver foot-noted the session by reminding the audience that the next ASQC Convention will be held in Cleveland, May 24-25, 1951, and inviting quality control personnel to plan to attend these meetings.

Bibliography

JOSEPH MOVSHIN, EDITOR

Assisted by the Editorial Committee, St. Louis Section, ASQC

On matters concerning the Bibliography Department, send correspondence, suggestions, and contributions to: Mr. Joseph Movshin, 9220 Old Bonhomme Road, St. Louis 24, Mo.

APPLICATION—AUTOMOTIVE INDUSTRY

HOW FORD APPLIES STATISTICAL QUALITY CONTROL, Roscoe M. Smith, Director of Quality Control

(Production Engineering and Management, v. XXV, n. 3, March 1950, p. 51)

A very interesting story of Quality Control working in Ford's Parts and Equipment Manufacturing Division. It shows the tie-in of Quality Control with Engineering Design, Purchasing, and Manufacturing. Quality control takes hold of a new product in its early stages and never lets go. When the new product finally reaches the production line, Quality Control in its statistical form is ready to take over.

APPLICATION—CHEMICAL INDUSTRY

QUALITY CONTROL OPPORTUNITIES FOR CHEMISTS, Kenneth C. Longman, Ethicon Suture Laboratories Inc., New Brunswick, N. J.
(Chemical & Engineering News, v. 27, n. 47, Nov. 21, 1949, p. 3481)

This is a very short article indicating the possible value of quality control to chemists and the chemical industry.

APPLICATION—ELECTRICAL INDUSTRY

FREQUENCY-RESPONSE CONTROL CHARTS, A. B. Mundel, Sonotone Corp.
(Electrical Engineering, v. 68, n. 10, Oct. 1949, p. 862)

The $\bar{X}$ and R charts are used to control frequency-response characteristics of electro-acoustic receivers by control of the critical regions alone.

QUALITY CONTROL IN RADIO TUBE MANUFACTURE, J. Alfred Davies, G. E. Corp. (IRE Proceedings, v. 36, n. 5, May 1949, p. 548)

Discussion of the use of SQC methods in the radio industry. Control methods for assembly or inspection which uses a combination of sampling for attributes and a control chart for percent defective are used, as well as finished-tubes control by use of median control chart and double sampling. Control chart for finished tubes is discussed and analyzed.

APPLICATION—FOOD INDUSTRY

DEVELOP NEW TEST FOR GAGING LEAKAGE FROM FROZEN FRUITS & BERRIES, T. W. Kethley, W. B. Crown and F. Bellinger, Georgia Institute of Technology
(Food Industry, v. 21, n. 2, Feb. 1949, p. 102)

In general this article discusses problems of the frozen food industry rather than Quality Control as such. Of interest, however, is the use of the standard deviation and the determination of significant differences of two means.

APPLICATION—METAL WORKING

QUALITY CONTROL IN THE PRESS DEPARTMENT, Clifford W. Kennedy, Federal Products Co.
(Tool and Die Journal, v. XVI, n. 2, Feb. 1950, p. 44)

The author uses this article to make a very elementary reference to c charts.

MECHANIZING QUALITY CONTROL, Clifford W. Kennedy, Federal Products Co. (Modern Machine Shop, Jan. 1950, p. 150)

The author describes what he called a "two out of three" system. No basis for the derivation of the tables is given.

APPLICATION—MISCELLANEOUS

QUALITY CONTROL FOR FLAT GLASS, F. L. Bishop & F. W. Mowrey, American Window Glass Co.
(Ceramic Industry, April 1950, p. 115)

Very general discussion on setting up a control program.

TAILOR-MADE CONTROL SYSTEM BOOSTS QUALITY PERFORMANCE, J. J. Montresor, Consulting Engineer, Monroe Calculating Machine Co., Orange, N. J.
(American Machinist, v. 94, n. 9, May 1, 1950, p. 96)

Quality Control aimed at small lot orders. Application to machine set-up. Illustrated with charts and tables.

APPLICATION OF STATISTICAL METHODS TO PAPER TESTING, J. H. Toulouse, Chief Engineer, Quality & Specification Dept., Owens-Illinois Glass Co., Toledo, Ohio
(Tappi, v. 35, n. 1, Jan. 1950, p. 44)

An introduction to the application of statistical methods to paper testing. The laws of probability, frequency distribution, sampling and the use of control charts are considered.

NATURAL AND SYNTHETIC RUBBERS, N. Bekkedahl, Bureau of Standards.
(Analytical Chemistry, v. 22, n. 2, Feb. 15, 1950, p. 253)

An article on analytical methods pertaining to natural and synthetic rubbers. Included are several references to statistical methods.

PLANNING INTERLABORATORY TESTING OF TEXTILE MATERIALS
(A.S.T.M. Standards, v. 5, 1949 p. 54)

A very comprehensive report on the setting up of an interlaboratory survey by SQC methods. Charts, sample calculations etc. are given.

STATISTICAL QUALITY CONTROL AS APPLIED TO STAMPING PRODUCTION, F. C. Schulze, Hunter Spring Co.,

Landsdale, Penn.
(Industrial Sheet Metal, v. II, n. 7, April 1950, p. 7)

Mr. Schulze outlines the uses of Frequency Charts in various operations of a stamping process. He illustrates the comparisons made possible between tools, methods, suppliers, machine settings and many other factors. Of special interest are the frequency tabulations used to spot tool wear, and thereby establish a reset interval. He concluded that such a system can not be effective without cooperation between management and inspection.

REMARKS ON QUALITY CONTROL IN THE GLASS CONTAINER INDUSTRY, K. C. Lyon, Armstrong Cork Co.
(The Glass Industry, v. 31, n. 4, April 1950, p. 177)

Discussion on the possibilities of applying SQC to inspection operations in Glass Container Manufacturing.

QUALITY CONTROL OF FACTORY MIXED BATCHES OF RUBBER, P. E. Gnaedinger, Dominican Rubber Co. Ltd., Canada
(Rubber Age, v. 64, n. 6, March 1949, p. 711)

Control chart methods can assist in controlling the uniformity of batches of compound rubber stocks by interpretation of tests on measurable qualities, analyzing charts from process recorders, and providing a continuous record of various inspections. Control charts can be used to show: the difference in variability between two stocks of similar purpose and nature; the effect of changing an operator; the variation of quality. Examples of charts and applications are shown.

MODERN QUALITY CONTROL APPLIED TO COMPOUNDING, Anthony Oladko, Johnson & Johnson
(Rubber Age, v. 65, n. 1, April 1949, p. 44)

The author points out how control chart technique can be applied to the compounding process—especially to the plasticity characteristics. Charts were constructed (X & R) and limits determined. Both first shift operator and second shift operator data were plotted on same chart. Out-of-control points were assigned to

(1) Raw material variation;
(2) Time cycle and procedure variation;
(3) Temperature variation.

Student's "t" test was applied to determine the variability between operators.

STATISTICAL SAMPLING OF UPPER LEATHER, Mann, Randall, Mandel, Kilduf, Charles
(Leather & Shoes, v. 118, n. 2, July 1949, p. 32)

Study of variation of leather, —tensile strength, stitch tear, bursting strength, tongue tear, elongation etc. over area of side. Each side was cut into 21 blocks to determine which block could be determined average for inspection purposes.

GRAPHIC RECORD IN RECEIVING INSPECTION, W. A. MacCrehan, Jr., Professor of Administrative Engineering; New York University
(Purchasing, v. 28, n. 2, Feb. 1950, p. 99)

Statistical techniques applied to inspection of purchased materials; including sampling

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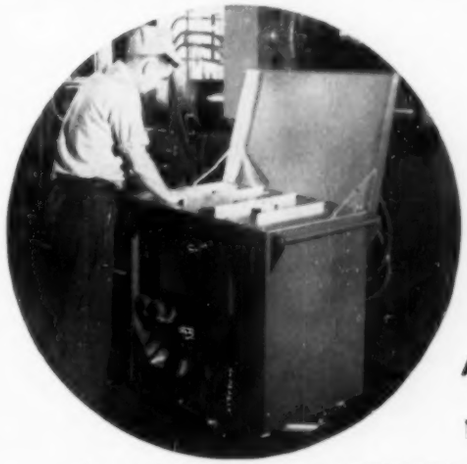

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tables.

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ENGINEERING & EXPERIMENTS

INTERCHANGEABLE TOLERANCES — ARBITRARY OR NATURAL? Dorian Shainin, Chief Inspector, Hamilton Standard Division, United Aircraft Corp.
(Machine Design, v. 21, n. 6, June 1949, p. 130)

Discusses controlled and uncontrolled processes as they affect assembly of two or more components. Suggests means for finding natural tolerances of components, and of combining these for assembly. Contains a table of "Natural Machine Tolerances."

SPECIFYING DESIGN TOLERANCES, Edmond L. Bates, Bates & Boswell, Los Angeles, Calif.
(Machine Design, v. 21, n. 3, March 1949, p. 120)

Distribution curves are used to illustrate problems of specifying design tolerances. The statistical analysis of the tolerance problems through these distribution curves is discussed.

WHAT DO MATERIALS TESTS REALLY TELL THE DESIGNER? H. W. Gillett, Chief Technical Adviser, Battelle Memorial Institute, Columbus, Ohio
(Machine Design, v. 21, n. 10, Oct. 1949, p. 96)

This article describes the extent and limitations on standard, generally used physical property tests such as Hardness, Modulus of Elasticity, etc. The very definite limitations of such test data for design purposes are particularly noted. Not a Quality Control article as such, but with possible thought provoking ideas for Quality Control Engineers.

THE FALLACY OF THE BEST TWO OUT OF THREE, Report of the findings of the National Bureau of Standard's Statistical Engineering Laboratory.
(Electrical Engineering, v. 68, n. 10, Oct. 1949, p. 854)

The practice of discarding one of three measures that appears different from the other two is discussed. Data from an empirical study is presented showing the frequency of various ratios of differences.

CHANCE LAWS AID DESIGNER IN ASSIGNING TOLERANCES, Based on a paper by Dorian Shainin, Hamilton Standard Division, United Aircraft Corp.
(SAE Journal, v. 57, n. 3, March 1949, p. 24)

The Shewhart control chart is presented as giving a graphical record of quality produced by each piece of equipment in the shop. These data can form a basis for assigning natural tolerances. A "Nomogram for combining tolerances statistically", and a "Chart for statistically combining two or more equal component tolerances" are given.

MANAGEMENT & PERSONNEL

QUALITY CONTROL AS AN AID TO MANAGEMENT, Abstract from a paper presented by J. M. Juran, N.Y.U. at the ASME Annual Meeting in New York
(Machine Design, v. 22, n. 3, March 1950, p. 198)

SAMPLING PLANS & RELATED TOPICS

SAMPLING PLANS REDUCE INSPECTION COSTS, (Notes from the National Bureau of Standards)
(Journal of the Franklin Institute, v. 248, n. 5, Nov. 1949, p. 440)

Statistical Engineering Laboratory of the National Bureau of Standards has developed a modified double sampling plan saving 20-40% of average costs. Inspection procedure remains the same except for interruption after predetermined number of units inspected. If, then, the units pass level, sampling is stopped; otherwise it is continued.

THEORY & APPLICATION—GENERAL

EVALUATING QUALITY WITH THE STANDARD DEVIATION, Clifford W. Kennedy
(The Tool Engineer, v. XXII, n. 1, Jan. 1949, p. 26)

Setting up $\overline{X}$ and Sigma charts for measuring pistons; methods of figuring $\overline{X}$ and Sigma, and probability of measurement falling within prescribed limits.

GRAPHICAL STATISTICS — AN ENGINEERING APPROACH, L. R. Hill and P. L. Schmidt,

Westinghouse Electrical Corp.
(Westinghouse Engineer, v. 10, n. 2, March 1950, p. 120)

The frequency distribution is used to illustrate and analyze the results of various product process and quality characteristics. The cumulative frequency distribution plotted on probability paper is also used in process analysis. Methods for giving the percent of product within intervals are given.

LOW COST THROUGH HIGH QUALITY, Warren R. Purcell, Manager of Quality Control, Sylvania Electric Products, Inc., Salem, Mass.
(The Glass Industry, v. 30, n. 9, Sept. 1949, p. 501)

The organization and place of Quality Control is outlined. A comparison is drawn between SQC sampling and the old inspection system, indicating the flaws in the latter. "Classified sampling", or the selection of a sampling plan based on past quality performance of the product is discussed.

Book Reviews

A. C. Cohen, Jr., *Editor*

INTRODUCTION TO THE THEORY OF STATISTICS

Alexander M. Mood, McGraw-Hill Book Company, New York, 1950. 433 + XIII pp. $5.00. Review by William R. Pabst, Jr., Navy Department, Bureau of Ordnance, Quality Control Division, Washington, D. C.

Correspondence and suggestions concerning book reviews should be sent to:
Professor A. C. Cohen, Jr.
Department of Mathematics
University of Georgia
Athens, Ga.

When you have satisfied yourself that knowledge of statistics is important, this book provides a means of exploring the theory of mathematical statistics. It covers the usual topics of mathematical statistics: probability and combinatorial methods, distributions, discrete, continuous and special, sampling and sampling distributions, tests of hypothesis, experimental designs and analysis of variance, sequential tests, and distribution-free or non-parametric methods. This is much the ground covered in the books by Hoel and by Weatherburn. Mood's book is more rigorous in treatment, and therefore somewhat more difficult to read and more rewarding from study.

Mood's book is developed from a set of lectures in mathematical statistics and there is every evidence of straightforward progression of the subject. The book should provide an excellent text for such courses. Each chapter is carefully written and the terminology and mathematical formulation is carefully explained in the introductory chapters. A previous course in calculus but no previous work in statistics is required. The book presents functional notation, elementary set theory, and the elementary algebra of determinants and matrices in an understandable and yet elegant way. The author has been conscious of avoiding what he calls "mathematical frills." The book contains excellent presentation of beta and gamma distributions, chi-square, and t distributions. The part on distribution-free methods is an excellent source of new material. The book thus provides a handy workbook and reference book for statisticians at all levels.

The book also contains many excellent insights on the nature of statistics as shown in the short explanation of the role of the normal distribution. Observing that a great many of the techniques in applied statistics are based on the normal distribution, the author explains this as follows: Page 143:—"Thus if a complete theory of statistical inference is developed based on the normal distribution alone, then one has in reality a system which may be employed quite generally, because other distributions can be transformed to the normal form." He also points out that when the distribution characteristics are not known, the distribution-free methods are applicable.

The absence of references, beyond a dozen general works in the field, is one of the serious shortcomings of the book. For instance, there is no reference to Hotelling's penetrating work, the generalization of which forms a large part of some of the chapters. Also in coverage of material as well as in references, Mood neglects his own work in the development of sensitivity and intensified testing, material which might be extremely useful for students in quality control. Those who use the book for independent study may also complain that the problems which are given to supplement the text are not solved. Solution of the problem might furnish useful guide lines for students.

Like people and institutions, this book takes some of its character from the environment in which it was created. It was developed from a course of lectures at Iowa State University. Also at Iowa State, Professor Snedecor's practical course in Statistical Methods is given. Many will agree that Snedecor possesses an amazing ability to inspire his readers with the art and philosophy of modern statistics, in illustrating the application of advanced techniques to problems without mathematical development. But to go on from Snedecor one must turn to more solid and mathematical foundations. Probably Mood's course and the excellent book emerging from it was stimulated by the interest in statistics created by Snedecor and by the need to go beyond its limits.

The same effect may be produced on some who have come upon statistical methods through the control of quality. Quality Control methods, adequate as they are in filling many of the needs of industry for interpreting test data obtained from control of operations and inspections, leave much to the imagination of the inquisitive. The thirst for knowledge of more powerful methods of modern statistics induced by the successful application of control charts and elementary sampling theory may be satisfied by study of Mood's book.

AMERICAN SOCIETY NEWS

ANNUAL MEETING—1950

The fourth annual meeting of the American Society for Quality Control, Inc., was held at the Milwaukee Auditorium in Milwaukee, Wisconsin, on June 1, 1950. At that meeting the following officers were elected by the Society to serve during the 1950-51 fiscal year:

PRESIDENT: Wade R. Weaver
Republic Steel Corporation
Cleveland, Ohio

VICE PRESIDENT: Martin A. Brumbaugh
Bristol Laboratories, Inc.
Syracuse, New York

EXECUTIVE SECRETARY: Simon Collier
Johns-Manville Corporation
New York, New York

TREASURER: Alfred L. Davis
Rochester Institute of Technology
Rochester, New York

Officers elected at the annual meeting were presented to those attending the Annual Society Banquet held at the Hotel Pfister on Thursday night, June 1.

In addition to voting for Officers, Society members voted on the question of new constitutional amendments. The Committee of Tellers reported at the annual meeting that all proposed amendments had been approved.

A complete report of the annual meeting, together with the reports of the Board of Directors, the Executive Secretary, and the Treasurer, will be presented in the September issue of Industrial Quality Control.

EXECUTIVE COMMITTEE MEETS

The Executive Committee met in Milwaukee immediately before and immediately following the National Convention. These meetings were held at the Hotel Pfister on Wednesday afternoon, May 31, and on Friday evening, June 2.

For the first time in the history of the Society, every member of the Executive Committee was present for the meeting.

The Executive Committee reviewed Society operations during the past year and made decisions on a number of important matters that are reported elsewhere in this issue of the magazine.

BUSINESS MANAGER FOR INDUSTRIAL QUALITY CONTROL APPOINTED

The Executive Committee has appointed Raymond S. Saddoris of the Milwaukee Section as Business Manager of Industrial Quality Control. This is a key step in effecting the organization now required under expanded publications operations.

Mr. Saddoris will work closely with Alfred L. Davis, Treasurer, and Mason E. Wescott, Chairman, Editorial Board, in carrying through these responsibilities.

All matters relating to advertising and the business side of magazine operations should be referred to Mr. Saddoris as Business Manager.

NEW SECTIONS OF THE SOCIETY

At its meeting in Milwaukee on May 31, the Executive Committee approved the applications of the San Francisco Bay Area and Rhode Island quality control groups for recognition as Sections of the American Society for Quality Control.

The San Francisco Bay Area Section becomes the 41st Section of the Society and the term of its National Director will run to June 30, 1951.

The Rhode Island Section is the 42nd Section of the Society and the term of its National Director will expire on June 30, 1952.

The Society warmly welcomes these two new Sections, located as they are in important industrial areas.

BOARD OF DIRECTORS MEETS

The Board of Directors of the Society met in Milwaukee on Saturday, June 3, following the Annual Convention. The meeting was attended by Directors from all Regions of the Society.

Reports were received from the Officers concerning operations of the Society during the past year. Reports were also received from Chairmen of Society Committees concerning the work and plans of these committees.

A tentative budget for the 1950-51 fiscal year was adopted, and other plans were made for Society activities in the coming year.

MEMBERSHIP ON THE BOARD OF DIRECTORS

The terms of the representatives of the following Sections on the Board of Directors expired on June 30, 1950:

Buffalo	Muncie
Chicago	N. E. Indiana
Cincinnati	Pittsburgh
Dayton	Rock River Valley
Denver	St. Louis
Georgia	Southern Tier
Greater Muskegon	Tennessee
Illinois	Toledo
Iowa	Toronto
Milwaukee	Washington

In order that the new Board may be completed as early as possible and particularly that the new Executive Committee may be constituted and begin functioning promptly, all of the above Sections which have not appointed Directors for the forthcoming term are urged to do so immediately and to notify the Executive Secretary of the names and addresses of their selections.

Present Directors are of course eligible for reappointment for succeeding terms, where this is the wish of the Section concerned. Under the Constitution, present Directors will remain in office until their successors have been duly appointed and qualified.

MEMBERSHIP OF THE EXECUTIVE COMMITTEE

The terms of the Regional Directors for the Central and Midwest Regions of the Society expired on June 30, 1950. As soon as all Sections in each of these Regions have completed selection of their Directors, the Directors in each Region will choose a new Regional Director from among their own number.

In those cases where a Regional Director is reappointed as a Director to represent his Section, he is, of course, eligible for selection as Regional Director where this is the wish of the Directors concerned.

In order that the new Executive Committee may be constituted and begin functioning as soon as possible, all Sections in the Central and Midwest Regions having Directors whose terms expired on June 30, 1950, are

particularly urged to appoint their new Directors immediately and to notify the Executive Secretary of their selections.

MORE STRINGENT REQUIREMENTS FOR SENIOR MEMBERSHIP

Under the provisions of Section 4d. of the Constitution, the age and experience qualifications required of applicants for Senior Membership during the 1949-50 fiscal year have been age 26 and 4 years' experience, respectively.

Effective July 1, 1950, the Constitution requires that these age and experience qualifications be increased to age 27 and 5 years' experience. These new requirements will now accord with full status of Senior Membership as contemplated under the Constitution, and will remain in effect permanently.

ELECTRONICS TECHNICAL COMMITTEE

In order to assist quality control developments in the electronics industry, the Society has established an Electronics Technical Committee. The Committee is composed of: Leon Bass, Chairman; R. F. Rollman, Vice Chairman; and A. B. Mundel, Secretary.

The specific projects which will receive initial consideration by the new Committee are:

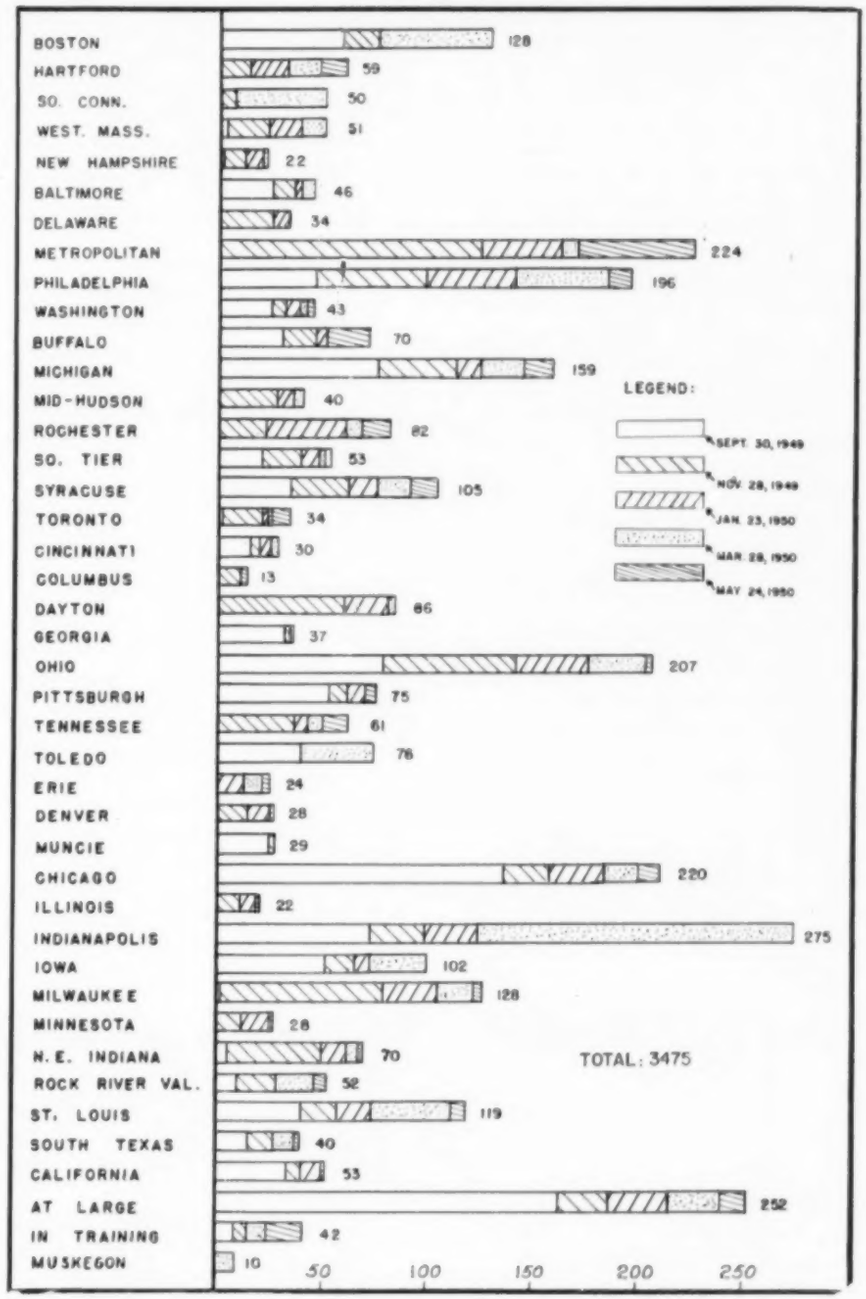
1. Preparation of a bibliography covering quality control applications in the electronics industry.
2. Assistance to the Editorial Board, when requested, in reviewing papers dealing with electronics quality control applications.
3. Assistance to convention committees in developing quality control programs for national conventions.
4. Service as a clearing-house for matters of quality control in the electronics industry, so that Society members interested in electronics quality control applications can have contact with others in the field.

The Electronics Technical Committee held its first formal meeting on Friday, June 2, at the Society Convention in Milwaukee.

ASQC CONVENTION—1951

The Fifth Annual Convention of the Society will be held in Cleveland on Friday and Saturday, May 24 and 25, 1951. As detailed plans for the meetings are worked out, announcement will be made of them in the subsequent issues of Industrial Quality Control.

BAR-CHART OF PAID-UP ASQC MEMBERS PER SECTION AS OF MAY 24, 1950



MEMBERSHIP

The chart shows real progress in membership during the current year. As of September 30, 1949, there were 36 Sections; this final chart shows 40. On June 30, 1949, there were 2639 corporate members; on May 24, 1950 there were 3475, against a goal of 3500 with five weeks still to go.

The "over 200" Sections now include Metropolitan as well as the Indianapolis, Chicago, and Ohio Sections. Seven other Sections are over the 100 mark, one of which, Philadelphia, may exceed 200 by June 30th.

Congratulations to each of the Sections, to Society members as a whole, and to Section and National officers for working so successfully toward a common goal. A strong and enduring ASQC depends primarily upon an active and growing membership. Let us set our sights for next year on a minimum of 5000 corporate members. We can attain this goal. Let's do it!

J. R. STEEN, *Chairman*, Committee on Membership

BASIC QUALITY CONTROL COURSE

University of Colorado
Boulder, Colorado, August 14-25

A ten-day intensive training course in Quality Control by Statistical Methods will be offered by the College of Engineering (including the Departments of Applied Mathematics and Mechanical Engineering) at the University of Colorado, Boulder, Colorado, August 14-25, 1950. Staff for this course will include Dr. Lloyd Knowler of the State University of Iowa, Dr. Mason Wescott of Northwestern University and Professor John Henry of the University of Illinois, as well as additional faculty members from the Colorado area and representatives from industry.

Instruction will follow, in general, the pattern laid down in previous courses of this type. Basic control charts and sampling techniques will be emphasized along with brief descriptions of other statistical techniques useful to industry and business. Some knowledge of algebra and statistics will be useful but not essential. The course will be intensive, mathematically non-technical, and practical.

Tuition will be $100.00 per person for the ten-day period and later follow-up, and will include all books and supplies. Accommodations will be available in modern University housing facilities for rates from $23-$32 per week, including meals, or rooms and cabins may be obtained in hotels and tourist camps off the campus at considerably higher rates. Further inquiries and applications for enrollment should be addressed to Professor A. R. Deschere, Department of Mechanical Engineering, University of Colorado, Boulder, Colorado.

MICHIGAN QUALITY CONTROL COURSE

The University of Michigan will offer a ten-day course in Statistical Quality Control August 21-31, inclusive on the campus in Ann Arbor. This will be a repetition of the successful introductory course given in August in 1948 and 1949. It will be intensive, mathematically non-technical, and practical.

Professor C. C. Craig will be in charge, and the staff will include Professors I. W. Burr of Purdue University and E. G. Olds of Carnegie Institute of Technology and Mr. E. C. Yehle of the University of Michigan. The registration fee of $100 per person includes a textbook and a syllabus of the course.

For further information write to Professor C. C. Craig, 106 Rackham Building, University of Michigan, Ann Arbor, Michigan.

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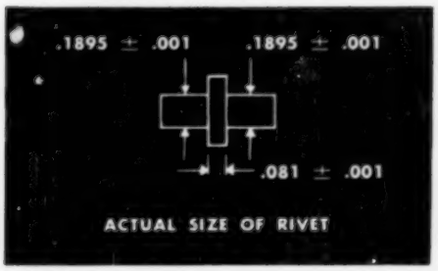
Dayton 1, Ohio, U.S.A.

3,000,000 Dimensions inspected per month!



"Unprecedented savings in cost, quality, and assembly" with this Federal Electronic Sorting Gage.

That's what the owner said — This gage has improved the dimensional quality of chain rivets and has eliminated assembly problems to such a degree that the Assembly Department now refuses to accept rivets until they are inspected by this Automatic Gage. Result — two more Federal Electronic Sorting Gages are on order *right now.*

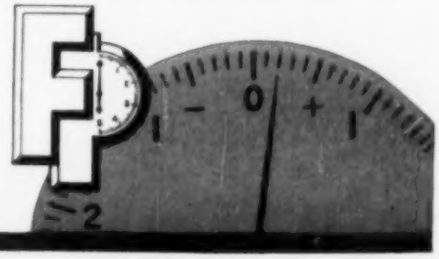
Thirty years of basic gaging know-how, plus standardized electronic components, put Federal Automatic Gages years ahead in performance. We build these gages to exactly meet your requirements. Our wide experience has served all types of industries. Automatic Gages are controlling the quality of all types of products from rivets to glass tubing, from fountain pens to insulator plates.

Any combination of units is available:—manual loading and disposal, automatic loading and disposal, and combinations of either manual or automatic systems. Electronic Sorting Gages can also be built to fit in your conveyor line—or components can be supplied for you to build into your own system. Other modifications are available for continuous measurement of strip material and for automatic sizing control of machine tools. All these applications are now in successful use.

Learn how automatic and semi-automatic gages can be applied to your requirements. Write for more details—and tell us about your own problems. No obligation, of course. Federal Products Corporation, 1157 Eddy Street, Providence 1, R. I.

A FEW OF THE MANY SUCCESSFUL APPLICATIONS OF THIS MODERN GAGING SYSTEM

TYPE OF PART	DIMENSIONS	NUMBER OF SIZE GROUPS	TOLERANCE PER GROUP	PARTS PER HOUR
Disc	Thickness	2 — OK plus too thick or too thin	.0005"	3600
Movement Plate	Depth	4 — two OK plus too deep and too shallow	.002"	3600
Glass Tubing	Size	2 — Good and Bad	.005" to .040"	3600 to 4800
Piston Pin	O.D. over full length — also taper	5 — three OK groups plus over and under sizes	.000067"	3600
Fountain pen barrel	O.D. and length	3 O.D. plus over and under O.D. and length	.002"	3600

FEDERAL

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